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The Cost of Illness of Exposure to Elevated Levels of PM_{10} in Baguio City Central Business District, Philippines

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THE COST OF ILLNESS OF EXPOSURE TO ELEVATED LEVELS OF PM_{10} IN THE BAGUIO CITY CENTRAL BUSINESS DISTRICT, PHILIPPINES

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Winona Bolislis, Dorothy Bantasan

EXECUTIVE SUMMARY

Particulate matter (PM) in the ambient air is a pollutant that is closely monitored due its known adverse health impacts on the populations exposed to its high concentration levels. It is a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air, consisting of sulfates, nitrates, ammonia, sodium chloride, black carbon, mineral dust, and water. Exposure to small particulates PM_{10} (of sizes ≤ 10 micrometers in aerodynamic diameter) and fine particulates $PM_{2.5}$ (of sizes ≤ 2.5 micrometers in aerodynamic diameter) put people at risk of mortality and morbidity from heart disease and stroke, respiratory diseases, and lung cancer (WHO 2014).

The Environment Management Bureau of the Department of Environment and Natural Resources, Cordillera Administrative Region Office (EMB-DENR CAR) has been monitoring the PM_{10} levels in the Baguio Central Business District (CBD) since 2007 using the Continuous Automatic Ambient Air Quality Monitoring System. Among the major cities in the Philippines that EMB-DENR monitors PM_{10} levels (e.g., Metro Manila, Cebu), the Baguio CBD has the highest mean annual PM_{10} concentration levels. From 2007 to 2012, the six-year annual PM_{10} mean was measured at 83.2 micrograms per cubic meter (μg/m^3). This level is to be evaluated relative to the national standard set by the Philippine Clean Air Act of 1999, which defines the critical level for annual PM_{10} mean at 60 μg/m^3 and relative to the global air quality guideline (AQG) of 2005 set by the World Health Organization (WHO) at 20 μg/m^3. Notwithstanding the practical policy targets set above, the epidemiological community is unanimous in stating that there is no scientifically validated "safe" level of exposure to PM_{10} (or $PM_{2.5}$). The WHO AQG of 2005 is meant to set the minimum possible and feasible limit to mitigate against the expected adverse health impacts.

The Baguio City local government enacted its own Clean Air Ordinance in 2008 together with its implementing rules and regulations. The ordinance has established measures to regulate the flow of motor vehicles into the CBD, and enforced emission standards that the motor vehicles entering the CBD should meet. In the early years of the implementation of the city ordinance (2009–2011), the mean PM_{10} levels significantly declined. In the subsequent years (2011–2012), however, the PM_{10} mean levels appeared to be on the upward trend again. The city government is in the process of crafting its Local Environment Code, and is inviting stakeholders to contribute to the design of proposals that will improve air quality in the city.

This study was conducted to determine the health costs that air pollution imposes on the constituents of Baguio City. Specifically, the study is intended

1. to make the people, local government leadership, and relevant stakeholders aware of the magnitude of the socioeconomic costs of the adverse health impacts of being exposed to high concentration levels of air pollution in the Baguio CBD, and
2. to determine the social benefits of investing in less polluting modes of public transportation systems.

It is hoped that this study will spur the local and national governments and partners in the private sector to act by designing regulatory and policy measures and instruments that will significantly reduce the air pollution concentration levels in the Baguio CBD.

The study used the cost of illness (COI) approach to value the economic burden that households bear in terms of having a household member be treated for falling ill or for dying due to an air pollution-related disease. The type of illnesses related to acute (one-day) or long-term or chronic (one year or longer) exposure to PM_{10} or $PM_{2.5}$ were culled from the epidemiological literature. Data on the cost of treatment from illness per individual were obtained from a random survey of 398 households living within a

1.5-kilometer radius from the Baguio CBD PM_{10} monitoring station. The cost of premature death was estimated using the loss of productivity approach.

The study followed the methodology of Ostro (2004) and Martuzzi et al. (2002) to estimate the number of cases of mortality and morbidity due to exposure to levels of PM_{10} concentrations that are above a defined critical health standard. The values of the health risk coefficients per 10 $\mu g/m^3$ increment in PM_{10} were adopted from Martuzzi et al. (2002) for each of the health outcomes that were comparable with the available data from the Baguio Health Department Statistics on the incidence of mortality and morbidity according to identified causes. The base estimates of the attributable cases of mortality and morbidity used in this study were computed based on the WHO Health Guideline for long-term (annual) exposure to PM_{10} at 20 $\mu g/m^3$; this estimate served as the target or background level of PM_{10} such that the researchers could assess the effect of long-term exposure to the actual levels of PM_{10} in the Baguio CBD, with a long-term mean of 83.2 $\mu g/m^3$.

The results indicated that chronic exposure to PM_{10} concentration levels that were about four times higher than that of the WHO Air Quality Guideline for PM_{10} (set at 20 $\mu g/m^3$) have significant adverse health impacts on the exposed population. Around 157 annual cases of premature nontraumatic adult mortality were attributable to being exposed to PM_{10} concentrations at historical mean concentration levels. This amounted to around 14% of the total number of premature nontraumatic mortalities in Baguio City in 2013. These attributable cases were valued at PHP 53.3 million per year in terms of lost productivity. In addition, around 4,758 attributable cases per year of cardiovascular and respiratory illness were estimated, accounting for about 22% of all cases of the identified cardiovascular and respiratory cases of morbidity in Baguio in 2013. The direct cost of illness (i.e., costs of hospitalization, physician consultations, and medication) and the indirect costs due to lost days of the otherwise productive patients and caregivers amounted to around PHP 24 million per annum.

In sum, the COI due to exposure to local PM_{10} concentration levels relative to the WHO AQG of 20 $\mu g/m^3$ amounted to around PHP 77.4 million per annum.

1.0 INTRODUCTION

1.1 Background

The Baguio Central Business District (CBD) has one of the highest air pollution concentrations in the country. Since 2007, the Department of Environment and Natural Resources (DENR) has been monitoring the levels of finer particulates (PM_{10}) in Baguio. From 2007 to 2012, the annual mean concentration levels ranged between 71 $\mu g/m^3$ and 101 $\mu g/m^3$ and a six-year average of 83.2 $\mu g/m^3$; this figure is almost 40% higher than the Philippine Clean Air Act (CAA) of 1999 annual exposure standard of 60 $\mu g/m^3$. However, using the World Health Organization annual exposure air quality guideline (WHO AQG) of 20 $\mu g/m^3$ for PM_{10}, on the average, the Baguio CBD population is being subjected to long-term exposure levels that are four times higher than that of the WHO health standard.

In the second half of 2014, the Environmental Management Bureau, Cordillera Administrative Region Office (EMB-CAR) of the DENR installed a $PM_{2.5}$ monitoring facility at an open space in the City Burnham Park Lake area, which is about half a kilometer away from the CBD PM_{10} monitoring station. The levels of $PM_{2.5}$ are considered to be a better indicator than that of PM_{10} for determining the level of health risks of individuals from air pollution. However, the limited sample of real-time data for $PM_{2.5}$ concentration levels at the Burnham Park site up to the present time poses limitations on more robust estimates of the long-term mean levels of $PM_{2.5}$ for association with specified health impacts.

As mainly a commercial center, Baguio CBD does not host any industrial plants that may be alternative sources of PM_{10}. The main generators of the pollutant in the CBD are traced to the diesel-powered transport vehicles plying the CBD road network. The diesel-powered vehicles traversing the city roads consist mostly of public utility jeepneys (PUJs) and public taxi cabs. PUJs are vehicles assembled from relatively old but cheap used engines imported from other countries, with the existing fleet logging an average length of operation (as public transport) of about 17 years. On the other hand, the taxi fleet consists of a few brand new vehicles, with the rest being older vehicles with a current average length of service of around 11 years (WAMD 2013). According to the president of the Federation of Cordillera Operators interviewed in this study, about 90% of the taxi cabs servicing the city run on diesel engines. The gas-fed vehicles, nevertheless, generate other types of air pollutants.

Based on the figures cited by the Land Transportation Office CAR office, the combined numbers of PUJs and taxi cabs in the city run to around 7,300 units. On a daily basis, these vehicles are crammed within a small area consisting of the CBD that is densely populated by primary- and secondary-school students, university-level students, school teachers, other educational institution workers, and workers in the various government offices and private business establishments.

The adverse health consequences of elevated levels of PM_{10}, as well as the other related air pollutants from motor vehicles (NO_2, SO_2, CO, and O_3), are known to affect the segment of the population chronically exposed to these ambient air pollutants. Epidemiology literature has established the health risks associated with long-term (and even short-term) exposures to outdoor air pollution. Although the health risks could be established for the entire community exposed to particular pollutants, certain segments of the population are more susceptible to the same intensities of exposure. Among the more consistent health outcomes relate to infant, child, and elderly mortality from respiratory diseases associated with short-term (one to six days) exposure to PM_{10}. Two others relate to adult cardiovascular mortality and lung cancer associated with long-term exposure to the pollutant. A second set of health risks to the community relate to morbidity health outcomes, which include hospital admissions, emergency room visits, asthma attacks, bronchitis, respiratory symptoms, and lost school days or work (Ostro 2004).

This study aimed to establish the magnitude of the above health outcomes for the city population, and estimate their economic costs that could be directly linked to the elevated levels of PM_{10} in the Baguio CBD. Establishing and communicating the magnitude of the economic losses borne by the community and by the public health sector could catalyze an even more concerted action by the local (if not national) government to plan for and undertake the necessary policies, interventions, and investments that would lead to significantly reducing the PM_{10} concentration levels to which the local community is exposed.

The beneficial impact of an improved air quality on Baguio City rests not only on the potential gains of a healthier population, but also on the recovery of economic losses stemming from the rapid erosion of its reputation as a high-end tourist destination.

1.2 Research Problem

Baguio is popularly known as the country's "Summer Capital"; it is also known as the "City of Pines." For years, the city was able to maintain its reputation as a rest-and-recreation destination for local and foreign tourists, owing to its cool and pleasant climate (16–24 °C). Over the last two decades, however, the town has lost its once-natural title of the "cleanest and greenest" city, having gradually degraded one of its invaluable environmental assets—its once pristine pine-scented cool air.

When DENR shifted from using TSP (total suspended particulate) to PM_{10} as a measure of particulate matter concentrations in Baguio CBD, with the national long-term (annual) mean standard set at 60 $\mu g/m^3$, the highly elevated levels of the air pollutant recorded in the CBD exposed the gravity of the problem in the city. By 2010, the Baguio CBD PM_{10} concentration levels reached an annual mean of 101 $\mu g/m^3$. In 2009, the city government started implementing its Clean Air Ordinance, patterned after the Philippines Clean Air Act of 1999. One of the measures was the creation of the Roadside Inspection and Monitoring Team, vested with the authority to flag down suspected vehicles that generate high emission levels of pollution, to measure emission levels, and to apprehend such vehicles that do not pass the legal emission limits (for diesel- and gas-fed vehicles, respectively). Corresponding fines and penalties were levied on violators of the city ordinance. Since then, the recorded PM_{10} concentrations have declined gradually, reaching the low 70s in $\mu g/m^3$; but after 2011, the levels appeared to be on the rise again.

Figure 1 shows a snapshot of the behavior of the short-term exposure of the population to PM_{10} over a 24-hour period. The mean of the hourly PM_{10} levels were calculated over a seven-day span (14–20 December 2012). Figure 1 also shows the 24-hour standards set by the Philippines Clean Air Act of 1999 (150 $\mu g/m^3$) and the WHO short-term Air Quality Guideline (50 $\mu g/m^3$).

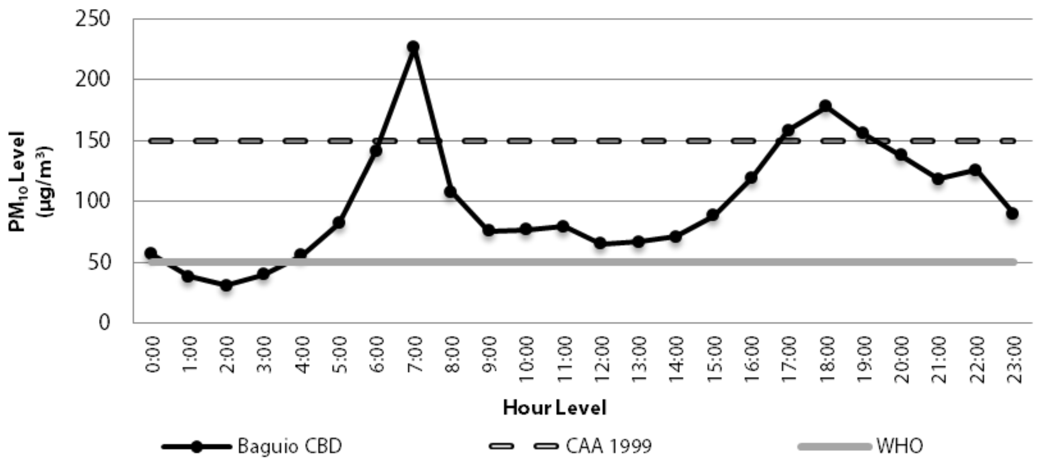

Figure 1. Mean hourly PM_{10} levels in the Baguio CBD, 14–20 December 2012, relative to the respective standards of the Philippines CAA of 1999 and WHO

Source of data: EMB-CAR, DENR
Note: Authors' calculations for seven-day mean levels.

Figure 1 appears to convey the information that the short-term mean PM_{10} levels of the Baguio CBD largely meets the Philippines CAA 1999 short-term standard for the pollutant. On the other hand, when the more stringent health standard advocated by the WHO is used, the opposite conclusion is reached.

The question then may be posed as "Up to what level should be the proper standard?"

On this matter, the epidemiology literature is consistent on the position that there is no evidence to support the existence of a threshold or "safe level" of PM_{10} concentrations below which the adverse health impacts of increases in PM_{10} (or $PM_{2.5}$) become negligible. Tests estimating the health risks associated with PM_{10} that set a conventional background level of 10 µg/m^3 against actual recorded levels have generated robust short- and long-term health risk coefficients. The shape of the relationship between PM_{10} levels and health outcomes is close to linear, starting from a 10 µg/m^3 background level (Pengelly and Sommerfreund 2004).

The Local Government of Baguio is searching for more effective policies and measures to reduce the concentration levels of air pollution in the CBD. In 2008, Baguio became one of the few local government units (LGU) that was able to design and to pass its own Clean Air Ordinance, in accordance with the National Clean Air Law of 1999. The city has enacted a "number-coding scheme" that bars a certain proportion of the motor vehicles from entering the CBD one-day-a-week, according to the ending number of the vehicle registration plate. The city has also implemented a road-side inspection, testing, and monitoring program that apprehends and penalizes vehicles with emission levels beyond the legal standards. However, the evidence is compelling that shows that high levels of PM_{10} concentrations in the CBD still persist. Thus, aside from continuing the strict implementation of its current vehicle emission control programs, the local government needs to become more decisive and should embark in bolder measures that could yield significant impacts to make substantial gains in improving the air quality that the city population breathes.

This research project documented the incidence and the magnitude of air pollution-related impacts and the size of the costs these impose on the community, with greater focus on the valuation of public health impacts. The purpose for doing such investigation—documenting the extent and severity of the air pollution problem and putting an economic value to the consequent health impacts—is to primarily provide strong empirical evidence on the magnitude of the economic costs of illness associated with chronic exposure of a population to air pollutants from public transport and mobile sources. It is hoped that by presenting and disseminating such evidence, this will mobilize the academe, civic groups, and community support to bring to the fore the gravity of the problem. Furthermore, it is hoped that such evidence would create social pressure on the regulatory agencies and local government to improve their compliance, surveillance, monitoring and enforcement functions, and get into the serious business in the stricter implementation of what is already provided for by law.

1.3 Research Objectives

In general, this study aimed to estimate the cost of illness of the exposure to high concentration levels of air pollution in the Baguio City CBD. The following are the specific objectives:

1. To identify the health impacts from short-term and chronic exposure to air pollutants from public transport in Baguio CBD; and
2. To estimate the socioeconomic costs of the health impacts of air pollution from public transport in Baguio CBD.

2.0 LITERATURE REVIEW

The cost of illness (COI) approach is generally applied to cases where the change in environmental quality has an impact on human health. A prerequisite, however, is to establish the crucial link between the environmental change and the change in health status; functions that relate specific health impacts with the level of exposure to a pollutant (of a set co-existing pollutants) and to control variables (e.g., socioeconomic characteristics, agro-climatic characteristics, geographic variables, among others) have to be estimated. The second link that needs to be established before the COI method can be employed is the link between the health impact and its monetary equivalent (Markhandaya et al. 2002; World Bank 2003b). Health impacts commonly investigated can be classified as (1) acute and chronic premature mortality; and (2) acute and chronic morbidity (or reduced life quality). The COI approach that uses medical costs and productivity loss provides a lower bound estimate of the value of avoided illness.

On the other hand, since cleaner air is a nonmarket good, the benefits that people derive from it may be assessed using stated preference methods such as the contingent valuation method (CVM) (Mitchell and Carson 1989 as cited in Indab, Harder, and Jin 2008; Carson 1999 as cited in Francisco 2011). Reductions in premature mortality may also be an impact of programs and policies that improve air quality. What is being valued here is the people's willingness to pay (WTP) in order to reduce the risk of dying from air pollution. This WTP is usually stated in terms of the value of statistical life saved (VSL) (WB 2003b).

CVM is a survey approach in which the respondents are presented with hypothetical scenarios or referendum, which will be used to state or disclose their preference. There are several ways to conduct CVM such as the open-ended, closed iterative bidding, payment card method, rank order method (Stavins 2009); but the generally preferred method is the dichotomous choice where respondents are simply asked to say "yes" or "no" on whether they are willing to pay an offered bid or not. The general preference for the dichotomous choice method lies in its close approximation of the real picture of market transactions, which are mostly "take it or leave it" in nature (Indab, Harder, and Jin 2008). Whittington (2002) discussed at great length the specifics and the do's and don'ts of conducting CVM surveys. The author emphasized on taking extra time and effort in creating the hypothetical scenario to ensure that respondents are quite clear as to what it is that researchers are asking them to put a value on. Among others, he also stressed the importance of having focus group discussions, split samples, validity tests and the influence of the manner of completing the survey questionnaire (e.g., face-to-face, drop-off, time to think) on the responses of individuals.

There is a vast set of epidemiology literature that establishes the relationship between short-term (acute) and long-term (chronic) exposure to PM_{10} and $PM_{2.5}$ (and related air pollutants such as CO, SO_2, NO_2, and O_3) and premature nontraumatic mortality between that of morbidity of populations exposed to the pollutants. While most of the earlier studies had been conducted in urban centers in developed countries in the US and Europe, more recent studies have now encompassed a growing number of developing countries in Latin America and Asia. A thorough review and documentation of these studies can be found in Martuzzi et al. (2002), Pengelly and Sommerfreund (2004), and Ostro (2004), among others.

The collection of studies undertaken in Europe consisted mainly of contributions to the APHEA (Air Pollution and Health: A European Approach) Project, which started in the early 1990s. The project's main objective has been "to investigate the short-term effects of air pollution on health establishing a European network of scientists based on a large amount of data that are analyzed in a uniform, updated, and standardized way" (Katsouyanni 2006). The results of the project included a range of estimates of health risk coefficients estimated from concentration-response functions across cities and across countries in Europe. The project results have been extensively used for health impact assessments by other investigators and for policy and regulatory purposes not only by government in the European community, but also by the US Environmental Protection Agency.

Most of the studies done in the US have been studies supported under the Health Effects Institute (HEI). HEI is an independent source of information on the health impacts of emissions from motor vehicles. The institute supports research on all major pollutants (i.e., carbon monoxide, ozone, nitrogen dioxide, and particulate matter). Among the most widely cited studies were two sets of investigations referred to as the National Morbidity, Mortality, and Air Pollution Study by Samet et al. (2000). The research included a critical review of the various methodological approaches and statistical methods in estimating health risks from air pollution from time series data. These studies have yielded health risk coefficients for both short-term and long-term exposures to known air pollutants.

The review of the epidemiology literature by Pengelly and Sommerfreund (2004) on estimating health-risk coefficients from concentration response functions (CRFs), including those from developing countries in Latin America and Asia, point toward the robustness of the range of estimates in predicting various health outcomes.

However, Sahsuvaroglu and Jerrett (2007) qualified that researchers need to be keenly aware of the existence of uncertainties when calculating the burden of illness (mortality and morbidity) attributable to air pollution; the adopted health risk coefficients rely on statistical estimates and particular assumptions that have inherent impreciseness. For the purpose of using these coefficients in quantifying the burden of illness from exposure to air pollution and for deriving policy implications from the results, a range of likely health outcomes should be considered, rather than focusing on single-point predictions.

In the last decade, tools have been developed (based on the health risk coefficients in the literature) to assess the environmental burden of disease from outdoor pollution. One of these practical tools uses PM_{10} or $PM_{2.5}$ as pollutants of focus; such tool has been developed by the WHO for application at the national or city level (Ostro 2004; Martuzzi et al. 2002). The four basic components of the assessment tool involve determining the following:

1. the ambient exposure of the population to PM_{10} or $PM_{2.5}$, based on fixed-site monitors, and a background or "target" concentration as point of comparison;
2. the population groups exposed to the pollutants and the type of health outcome of interest;
3. the incidence of the health effects being estimated (e.g., the underlying mortality rate in deaths per thousand people);
4. concentration-response functions from the epidemiological literature that relate the ambient concentrations of the pollutants to identified health effects, and provide the attributable fractions (AF) that are then used to estimate the magnitude of the health outcomes identified.

This tool has been applied in estimating the number of deaths from outdoor air pollution for Bangkok, Thailand (Ostro 2004).

Resosudarmo and Napitupulu (2004) applied an earlier version of the methodology devised by Ostro (1994) to estimate the health and economic impacts of the expected increase in air pollution in Jakarta, Indonesia due to the accelerating economic growth and the corresponding increase in motor vehicles and manufacturing activities, as projected over the years 2000–2015. The study estimated the health and economic impacts of various components of the *Action Plan* produced by the multi-sector Partnership for Clean Emissions using with-and-without emission control program scenarios. The pollutants considered were PM_{10}, SO_2, and NO_2.

Another tool, developed for Canadian cities, is known as the Air Quality Benefits Assessment Tool (AQBAT) (McKeown 2007). The structure of the tool essentially incorporates the basic components of the WHO tool, but also includes in the model the health risk coefficients associated with exposure to other air pollutants from transport vehicles. It moves one step further by estimating the economic costs of the burden of illness from transport pollution. AQBAT uses techniques to assign a monetary value to a health outcome.

The value attached to mortality ("value of a statistical life") is based on someone's WTP to reduce mortality risks or willingness to accept compensation to experience increased mortality risks (i.e., wage premiums for riskier jobs). The morbidity outcomes are valued according to costs of treatment (e.g., medical costs), lost productivity due to illness, and pain- and suffering-averting expenditures.

In a more recent paper, Chen, Tsai, and Yang (2015) have estimated the association between fine particulate air pollution ($PM_{2.5}$) and daily clinic visits for migraine in Taipei, Taiwan. Similar to the conditions in Baguio CBD, the authors have asserted that the origin of chemical pollutants in an urban setting is known to be principally due to road traffic. Under these conditions, $PM_{2.5}$ concentrations is a more reliable indicator than that of PM_{10} for measuring air pollution arising from human activity as related to the operation of motor vehicles. With time series data for $PM_{2.5}$ and PM_{10}, a high correlation coefficient of 0.79 has been found between variations in the two pollutants over time. The study focused on the short-term impacts of variations in $PM_{2.5}$ and the incidence of acute migraine, differentiating the significance of the impacts on warm days and cold days, respectively.

In the Philippine setting, a World Bank study done by Arcenas (2009) has provided estimates of the economic costs of environmental damage encompassing the value of health effects from indoor air pollution, outdoor air pollution, water, sanitation and hygiene. The assessment of health outcomes followed the basic procedures outlined above. The economic costs were estimated using human capital value (HCV) and VSL methods. Outdoor air pollution (OAP) mortality outcomes included adult lung cancer, adult cardiopulmonary mortality, and under-5-years respiratory mortality. OAP morbidity outcomes included under-15-years acute bronchitis, hospital admissions for respiratory diseases (acute bronchitis, acute lower respiratory infections [ALRI]), and respiratory symptoms [all ages]). As would be expected, VSL estimates of the cost of mortality and morbidity were higher than the HCV estimates. HCV is simply the value of lost income, whereas VSL is an attempt to estimate the value that individuals would assign for reducing the risk of premature mortality or the event of falling ill.

3.0 METHODOLOGY

3.1 Identifying Health Impacts from Exposure to Air Pollutants from Public Transport

In order to achieve Objective No. 1, the researchers conducted a thorough review of the international and local epidemiological literature on the link between air pollution and health and on the health risk coefficients of known air pollutants, in which the pollutant levels are known in Baguio and known to be robust across territories and countries.

The team employed key informant interviews (KII) with local cardio-pulmonologists in order to determine what the respective diseases were, their relative significance in Baguio City, the measures that physicians have undertaken to treat their patients according to the severity of symptoms, the prescribed medicines, and estimated cost figures in undertaking these measures. The KIIs followed a semi-structured interview instrument (Appendices 1 and 2).

The two categories of disease identified were upper respiratory tract infections (URTI) and lower respiratory tract infections (LRTI). URTI included allergic rhinitis, sinusitis, pharyngitis, tonsillitis, and tracheo-laryngitis. On the other hand, LRTI included chronic obstructive pulmonary diseases (COPD), chronic bronchitis, emphysema, asthma, and pneumonia.

3.1.1 Leading causes of mortality in Baguio related to air pollution exposure

The death statistics in Baguio City, published in the Annual Reports on The Philippine Health Statistics by the National Epidemiology Center of the Department of Health (DOH), refer to the deaths recorded to have happened in the locality. The city, being in the highly urbanized center of Northern Luzon, hosts a number of tertiary hospitals, which admit patients from the surrounding towns within the province (i.e., Benguet), within the region (i.e., CAR), and from the surrounding towns located in adjacent regions

(Regions 1, 2, and 3). The deaths recorded in these hospitals are recorded as deaths in Baguio City, although some of the diseased may not be residents of the city.

The Baguio City Health Department has culled from the general statistics the deaths of individuals whose addresses are stated to be in Baguio. On the average, for the years 2012–2013, around one-third of all deaths were those of individuals with stated residence outside the city. It is possible, however, that these individuals whose residential addresses were outside the city may have relatives residing within the city, and thus come occasionally as transients.

The data presented in Table 1 on the deaths attributable to the 10 leading causes of mortality refer only to individuals with an explicit residential address in Baguio.

Table 1. Leading causes of mortality in Baguio City, 2012 (rate per 100,000 population)

Cause of Death	Baguio 2012	Philippines 2009
Diseases of the vascular system	91	71
Cancer	63	52
Diseases of the heart	60	109
Pneumonia	36	46
Accidents	22	39
Diabetes mellitus	22	24
Nephritis, nephrosis, nephrotic syndrome (kidney)	18	15
Chronic lower respiratory diseases (COPD)	14	25
Tuberculosis, respiratory	9	28
Upper gastro-intestinal bleeding	9	–
Others	74	
TOTAL	**416**	
Cardiovascular-respiratory diseases	273	
Percent of total deaths	65.6	

Source: Baguio City Health Department (2014), DOH (2014a)
Note: The estimated 2012 population is 338,600.

Before discussing the leading causes of death related to exposure to air pollution, note the second leading cause: cancer. There are many types of cancer. In a recent study of Padawan (2014) on the causes of cancer deaths in Baguio, lung cancer ranked first on the list of cancer deaths over the period 2004–2013. Bearing in mind that lung cancer is the leading cause of cancer in Baguio City, referring back to Table 1, and then focusing on the first four leading causes of death, it could be stated that the top-four leading causes are directly or indirectly related to cardiovascular and respiratory diseases. At the top of the list are diseases of the vascular system, and running third are the diseases of the heart.

Moving further down the line, the diseases ranked eighth (chronic lower respiratory diseases, e.g., COPD) and ranked ninth (respiratory tuberculosis) are diseases identified by the epidemiological literature to be associated with chronic or long-term exposure to air pollution. Taking all cardiovascular and respiratory diseases together, they account for close to two-thirds of the causes of mortality in Baguio City in 2012.

3.1.2 Leading causes of morbidity in Baguio and diseases related to air pollution exposure

The Baguio City Health Department also releases data on the incidence of diseases among the population in Baguio. The recorded incidences, however, refer only to those reported in the public hospital (Baguio City General Hospital), in the main Health Center of the Baguio Health Department, and the Barangay Health Centers (village health centers). The private hospitals and private clinics in the city are not required to report visits by patients for treatment of diseases. The data on the rates of incidence as reported in Table 2, therefore, underestimates the true rates of incidence. The degree of underestimation is not known.

Comparing the top-10 causes of morbidity in Baguio with those at the national level, Table 2 at once reveals that there are a total of five classes of diseases ranked in the 10 leading causes in Baguio, but do not appear in the top-10 at the national level. Secondly, for all diseases commonly cited, the rates of incidence recorded in Baguio are uniformly much higher.

Among the top 10, the first two (i.e., acute respiratory infections (URTI and ALRI) and pneumonia) are classes of diseases that the epidemiology literature associate with exposure to air pollution. The other cardio-respiratory diseases in the list with links to air pollution exposure are hypertension (6th), bronchitis (8th), and asthma (10th). Summing up all the top-10 cases of morbidity, the cardio-respiratory diseases as a group account for more than half (55%) of the top-10 reported cases.

Table 2. Leading causes of morbidity in Baguio in 2012, and comparison of rates of incidence with the national averages in 2010 (rate per 100,000 population)

Rank	Diseases	Baguio City (2012)	Philippines (2010)
1	Acute respiratory infection	3,045	1,371
2	ALRI and pneumonia	1,865	624
3	Dog bite	1,548	
4	SVI	1,462	
5	Acute watery diarrhea	1,339	347
6	Hypertension	730	367
7	Dengue fever	648	
8	Bronchitis	647	374
9	Influenza	388	289
10	Asthma	387	
Total: Top 10		**12,060**	
Subtotal: Cardio-respiratory diseases		6,675	
Percent of top-10 causes (%)		55.3	

Sources: Baguio City Health Department (2014); DOH (2014b)
Note: ALRI = acute lower respiratory infection; SVI = systemic viral infection

3.2 Sampling Design

To achieve Objective No. 2, which is to estimate the socioeconomic costs of the health impacts of air pollution from public transport in Baguio CBD, a COI survey was undertaken. The Baguio City General Hospital Ethics Committee did not allow the research team to use its list of patients of respiratory and cardiovascular diseases as basis for obtaining the sample of respondents. Hence, the team resorted to a random sampling of households to obtain samples of households with incidence of having been diagnosed of identified respiratory and cardiovascular diseases.

Households hypothesized to be affected by the high concentration levels of air pollution in the CBD were those living near the city. The team designated a radius of 1.5 kilometers (km) from the city center to determine which would be included or excluded for the household survey. The city was divided into four quadrants, from which the sample of four barangays (villages) would be obtained via random sampling from each of the quadrants. The quadrants were (1) Quadrant 1 on the north-west (NW), (2) Quadrant 2 on the north-east (NE), (3) Quadrant 3 on the south-east (SE), and (4) Quadrant 4 on the south-west (SW).

In the chosen barangays, the researchers obtained the number of households per barangay; and from this set of data, a proportional sampling was drawn to determine the number of households to be interviewed for each sample barangay, and the subtotal for each quadrant. Figure 2 shows the city and barangays included in each quadrant. Meanwhile, the number of households in each barangay, the total number of households in each quadrant, and the number of sample households in each barangay and each quadrant are shown in Table 3. After the enumerators' training workshop and the pretesting of the survey instrument, the COI household survey was conducted from 13 January to 15 February 2014 in Baguio City.

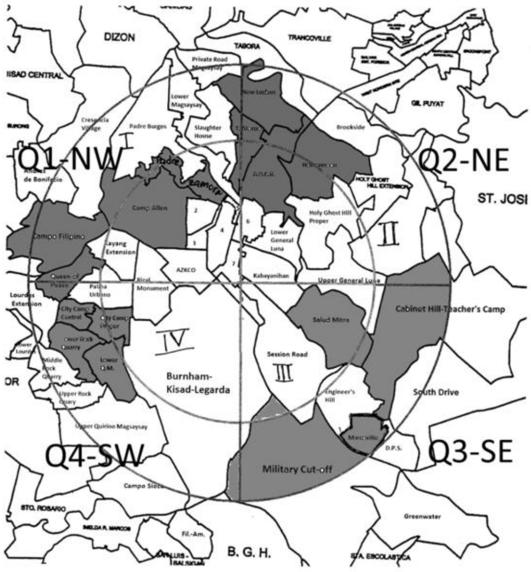

Figure 2. Location of the households in the sample barangays, by quadrant (1.5-kilometer radius)

Table 3. Sample households by quadrant and barangay, and main roads traversing barangays

Name of Barangay	Total No. of Households	No. of Sample HH	Main Roads Traversing the Barangay
QUADRANT 1 (12 barangays)	5,276		
Padre Zamora	543	34	Magsaysay Road, Padre Zamora Road
Camp Allen	663	22	Naguilian Road
Campo Filipino	420	15	Naguilian Road, Brower Road, Sepic Road, Roman Ayson Road, Sixto Gaerlan Road
Queen of Peace	518	33	Queen of Peace Road, Naguilian Road
Subtotal	2,144	104	
QUADRANT 2 (10 barangays)	5,184		
T. Alonzo	424	12	Rimando Road
ABCR	261	52	Rimando Road
Honeymoon	967	12	Rimando Road, Honeymoon Road
New Lucban	890	23	New Lucban Road, Rimando Road
Subtotal	2,542	99	
QUADRANT 3 (5 barangays)	2,280		
Salud Mitra	300	19	Bagumbayan Road (Happy Glenn Loop), Jungletown Road, Valenzuela Street, Leonardwood Road
Military Cut-off	445	17	Military Cut-off Road, Governor Center Road
Marcoville	151	12	Marcoville Street
Cabinet Hill	874	31	Leonardwood Road
Subtotal	1,770	79	
QUADRANT 4 (8 barangays)	3,451		
City Camp Proper	464	30	City Camp Road, Legarda Road
City Camp Central	463	29	City Camp Road, Legarda Road
Lower Rock Quarry	340	19	Jose Felipe Street, Lower Rock Quarry Road
Lower Quirino Magsaysay	495	42	Dr. Carino Street, Lower Quirino Magsaysay Road, Everlasting Street
Subtotal	1,762	120	
Total no. of households in sample barangays	8,218	398	

3.3 Cost of Illness Estimation

The following aggregate measures of the COI of PM_{10} ($PM_{2.5}$)-related illnesses were estimated in this study:

1. the aggregate magnitudes of cardiopulmonary mortality and morbidity, respectively, after estimating the attributable fraction (AF) due to air pollution;
2. the corresponding magnitudes of reduction in mortality and morbidity arising from the reduction in PM_{10} (and derived $PM_{2.5}$) concentrations from current historical levels to the WHO guidelines, using the robust health-risks coefficients (i.e., concentration-response coefficients per unit change in PM_{10} or $PM_{2.5}$) found in the empirical literature; and
3. the value of cost of mortality and morbidity saved from the reduction in pollution concentrations.

The methodology used in this study to estimate the relative risk coefficients (RR) for cardiovascular and respiratory diseases associated with exposure to PM_{10} was derived from the work of Martuzzi et al. (2002). Martuzzi et al. (2002) provided a most comprehensive review of the epidemiological literature in the US, EU, Latin America, and Asia on the health impacts of increasing concentrations of exposure to the pollutant PM_{10} and $PM_{2.5}$. For standardization, in country cases where $PM_{2.5}$ had been used as measure of the pollutant, the $PM_{2.5}$ values were converted to PM_{10} equivalents. Martuzzi et al. (2002) documented the ranges within which concentration-response estimates fell across countries. They determined the convergences, and then summarized the relations into RR estimates, which is interpreted as the increase in the risk of the health outcome occurring as PM_{10} concentrations increase by 10 μg/m^3 increments. The central values of the RR estimates were determined, and the 95% coefficient intervals (CI) for lower limits and upper limits were also provided to incorporate the factor of uncertainty in the central estimates.

From the RR coefficients, AF can be obtained directly, specifically

$$AF = {}^{(RR\ -\ 1)}/_{RR}\ . \qquad \text{Equation (1)}$$

This is again interpreted as the values for each additional 10 μg/m^3 concentration in PM_{10} exposure. Table 4 shows the risk coefficients of the various health outcomes that Martuzzi et al. (2002) used in estimating the health impacts of exposure to PM_{10} in eight Italian cities that had relatively high levels of PM_{10} concentrations.

Table 4. Martuzzi et al. (2002) estimates of relative risk coefficient and attributable fractions to total incidence of identified health outcomes

Cause	Central Estimate	CI: Lower Limit 95%	CI: Upper Limit 95%	AF per 10 μg/m^3 in PM_{10}
Adult mortality (30+)	1.026	1.009	1.043	0.0253
Hospital admissions for CVD	1.009	1.006	1.013	0.0089
Hospital admissions for respiratory disease	1.016	1.013	1.020	0.0157
Acute bronchitis in children (<15)	1.306	1.135	1.502	0.2343
Asthma exacerbation (children <15)	1.051	1.047	1.055	0.0485
Asthma exacerbation (adults 20+)	1.004	1.000	1.008	0.0040
RAD	1.094	1.079	1.109	0.0859
Occurrence of respiratory symptoms	1.070	1.020	1.110	0.0654

Source: Martuzzi, et al. (2002) (values per 10 μg/m^3 increments in the concentration of PM_{10})
Note: (1) AF = attributable fraction; CI = coefficient intervals; CVD = cardiovascular disease; RAD = days of restricted activity

The interpretation of the values would be as follows. As an example, for the incidence of all-cause mortality among adults aged 30 years and above, exposure to an additional 10 μg/m^3 concentration of PM_{10} in the ambient air by the exposed population would result in an additional 2.6% in adult mortalities within the population. Relative to a baseline level of PM_{10} concentration, with a 10 μg/m^3 increase in the concentration, 2.5% of the incidence of adult mortality would be due to elevated levels of PM_{10}, relative to a defined baseline. Relative to a defined baseline level (e.g., the WHO guideline for long-term values of $PM_{10} = 20\ \mu g/m^3$), higher increments in the actual values of PM_{10} in the ambient air would result in higher absolute values of the relative risk coefficients, and higher AF values.

The researchers used the equation of Martuzzi et al. (2002) to calculate the number of cases attributable to air pollution (*E*):

$$E = AF \times B \times C \times P \qquad \text{Equation (2)}$$

where:

B	=	population baseline rate of the given health effect,
AF	=	attributable fraction,
C	=	relevant change in air pollution, and
P	=	relevant exposed population for health effect.

The population baseline rate (*B*), which is defined as the "fraction of the exposed population that would be the health outcome assuming a baseline level (or no effects level) of air pollution" [Künzli et al. (1999) as cited in Martuzzi et al. (2002)] was computed as

$$\mathrm{B} = {}^{B_0}\Big/_{\left[1+(RR-1)\left({}^{C}/_{10}\right)\right]} \qquad \text{Equation (3)}$$

where:

B_0	=	observed rate of the health effect under current exposure,
B	=	baseline rate of the health effect under baseline exposure,
C	=	relevant change in air pollution, and
RR	=	relative risk coefficient per 10 $\mu g/m^3$, divided by 10 to get the risk per unit.

B_0 can be gathered from available health statistics, *C* from the monitoring network in the city, and *P* from census data.

3.3.1 Superiority of using $PM_{2.5}$ over PM_{10} in estimating the health impacts of changes in the concentration levels of ambient particulate matter

Between the finer particulate matter $PM_{2.5}$ and the coarser PM_{10}, high concentration levels of the former constitutes greater health risks. The finer particulates have impacts on the lower respiratory tract, while the coarser particulates are more associated with impacts on the upper respiratory tract. In the absence of local measures of $PM_{2.5}$, the measures of the concentration levels of PM_{10} were taken to proxy for the estimated concentration levels of $PM_{2.5}$.

Given the data on PM_{10}, the estimated concentration levels of $PM_{2.5}$ vary depending on the main generators of PM_{10} at the local level. Construction activities generate high concentrations of PM_{10} in the form of dust particles, but would generate relatively low corresponding concentrations of $PM_{2.5}$. On the other hand, when diesel-powered motor vehicles are the main generators of measured PM_{10}, the concentration levels of the generated unmeasured finer particulates are relatively much higher. Appendix 3 provides more detailed arguments on the attention that should be accorded to finer particulates based on the size distribution of particulate matter when the main source is diesel fuel combustion from motorized vehicles.

The WHO proposes a crude rule-of-thumb in estimating $PM_{2.5}$ concentration levels when data only exists for PM_{10}:

$$PM_{2.5}\ {}^{\mu g}/_{m^3} = 0.5 \times PM_{10} \times {}^{\mu g}/_{m^3}\ . \qquad \text{Equation (4)}$$

In 2014, DENR-EMB CAR set up a $PM_{2.5}$ and PM_{10} monitoring machine in Baguio City. However, it is located at the Baguio Burnham Park Lake area (Burnham Lake) and not at the exact location as the Baguio CBD monitoring station that generated the historical values of PM_{10}. The PM_{10} measures at the two different locations are not directly substitutable for each other, as the monitoring station at the CBD location captures PM_{10} concentration levels in a high motor vehicle-density area characteristic of the CBD, while the Burnham Lake station captures $PM_{2.5}$ and PM_{10} in a public park where motor vehicle passage is restricted. Thus, the monitored PM_{10} and $PM_{2.5}$ concentrations at the Burnham Lake station are expected to be significantly lower than those at the CBD station.

Nevertheless, as the $PM_{2.5}$ and PM_{10} are measured in the same location, a preliminary relationship between $PM_{2.5}$ and PM_{10} concentration levels can be established at the local level. Figure 3 shows the monthly mean concentrations of PM_{10} and $PM_{2.5}$, respectively, from May 2014 to May 2015.

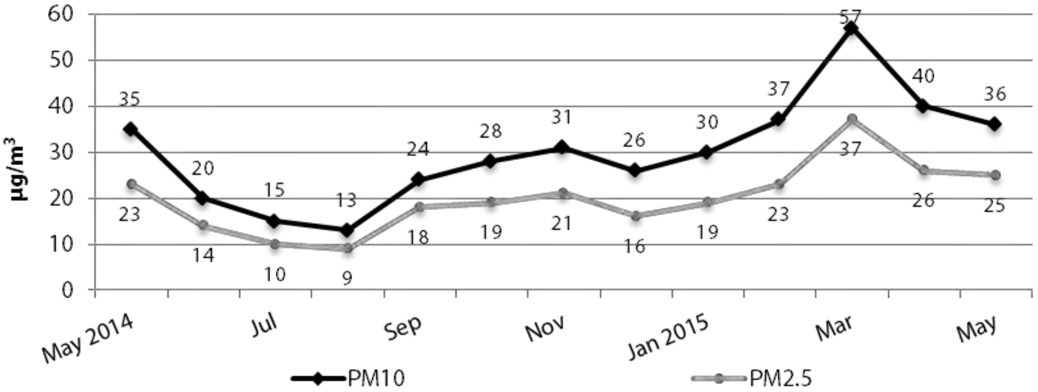

Figure 3. Monthly mean concentrations of PM_{10} and $PM_{2.5}$ at the Baguio Burnham Lake monitoring station (in $\mu g/m^3$)

Source: DENR-EMB CAR (2015)

Although the measured PM_{10} and $PM_{2.5}$ concentrations do not represent the long-term behavior of these particulates, there are already discernible patterns that are also consistent with the historical patterns of the PM_{10} measured at the Baguio CBD station over the years. One consistent pattern is the decline in the concentration levels during the rainy season (June, July, August), and then peaking up during the Baguio Panagbenga Festival period, carrying through the early summer vacation (February, March, April).

The data also reveals the relationship between the concentration levels of PM_{10} and $PM_{2.5}$ over time, although the data are still limited over a 13-month period. The movement of $PM_{2.5}$ closely tracks that of PM_{10}. Using a weighted mean procedure with the number of observations for each month as weights, the ratio of $PM_{2.5}$ to PM_{10} concentrations is 0.664. This ratio is even much higher than an estimate that would use the WHO rule-of-thumb with a value of 0.50. This validates the assertion that the main generators of PM_{10} in the Baguio CBD are the motorized vehicles.

Although no data on $PM_{2.5}$ are available for the CBD area where motor vehicle densities are extremely high, it can be asserted that the $PM_{2.5}$ concentration levels are higher than that at the Burnham Lake area. Moreover, the ratio of $PM_{2.5}$ to PM_{10} would also be likely to be higher than 0.664. Consequently, it can be asserted that the population of Baguio CBD are exposed to higher concentrations of $PM_{2.5}$ than previously presumed, using the rule-of-thumb.

4.0 RESULTS AND ANALYSIS

4.1 Profile of COI Household Respondents

For the COI survey, the researchers interviewed 402 household heads (HH) across locations. However, due to incomplete information, four of them were not included in the analysis. Hence, the total sample was 398 HH. Table 5 presents a brief profile of the HH respondents.

Table 5. Profile of HH head respondents, by quadrant, Baguio City

Characteristics	Q1 (n = 103) %	Q2 (n = 88) %	Q3 (n = 88) %	Q4 (n = 119) %	TOTAL (n = 398) %
Age					
≤ 30	14.6	20.5	13.6	8.4	13.8
31 to 40	25.2	15.9	20.5	16.0	19.4
41 to 50	22.3	14.8	18.2	16.8	18.1
51 to 60	17.5	21.6	21.6	27.7	22.4
> 60	20.4	27.3	26.1	31.1	26.4
Average	47.2	48.0	49.2	52.6	49.4
Sex					
Male	66.0	51.1	54.6	57.1	57.5
Female	34.0	48.9	45.5	42.9	42.5
Civil Status					
Single	8.7	18.2	17.1	9.2	12.8
Married	67.0	54.6	62.5	71.4	64.6
Widowed	10.7	22.7	13.6	14.3	15.1
Other	13.6	4.6	6.8	5.0	7.5
Highest Educational Attainment					
Elementary	10.7	2.3	2.3	8.4	6.3
High School or Vocational	35.0	28.4	35.2	42.9	35.9
College	52.4	67.1	60.2	46.2	55.5
Postgraduate	1.9	2.3	1.1	1.7	1.8
No Education	0.0	0.0	1.1	0.8	0.5

The average age of the HH heads interviewed was 49 years. Across locations, HH heads in Quadrant 4 were older, with a mean of 53 years. In general, HH heads were males (57%) with Quadrant 2 having about an even distribution in the gender of the HH heads. The majority of HH head respondents were married. In Quadrant 2, however, there was a significant proportion of HH heads who were already widowed (23%). In terms of education, the majority of the HH head respondents were college graduates (56%). Across locations, however, Quadrant 4 had a relatively even distribution between those who just finished high school per vocational school (43%) and those who finished college (46%).

Figure 4 presents the distribution of the respondents in terms of primary occupation. A significant proportion of the respondents were unemployed at the time of the survey (20%). Of those employed, there was about an even distribution on the type of employment between those self-employed (22%) and the next largest category, the skilled workers and OFW (19%). A very small proportion of the HH heads (10%) had a secondary occupation. Consistent with the relatively high unemployment rate of the surveyed HHs, coupled with respondents who were students boarding in shared dwellings, a significant proportion of the HH heads reported no income (28%). On average, the monthly reported net income was relatively low at PHP 13,195.

Compared to the data reported on the Family Income and Expenditure Survey (FIES) of the National Statistics Office (NSO) 2012, the average annual family income in CAR (where Baguio City is located) was about PHP 257,000 per year, which translates to about PHP 21,417 per month. This low average could arise from the significant proportion of household heads who reported no income (Figure 5).

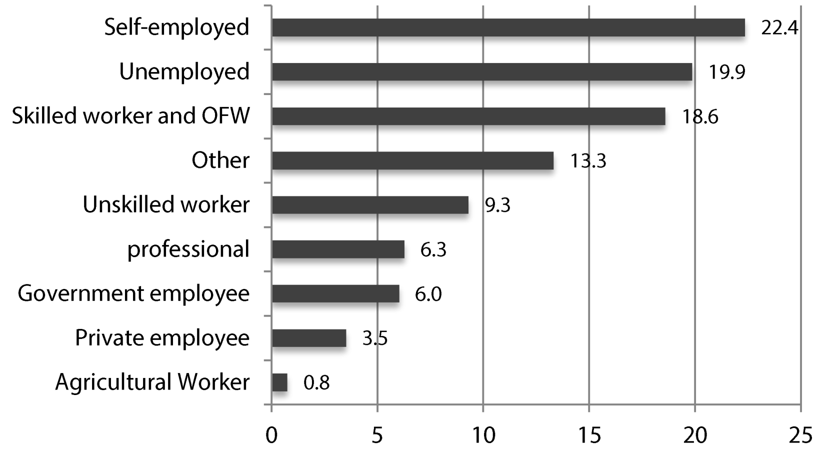

Figure 4. Distribution of HH head respondents by primary occupation

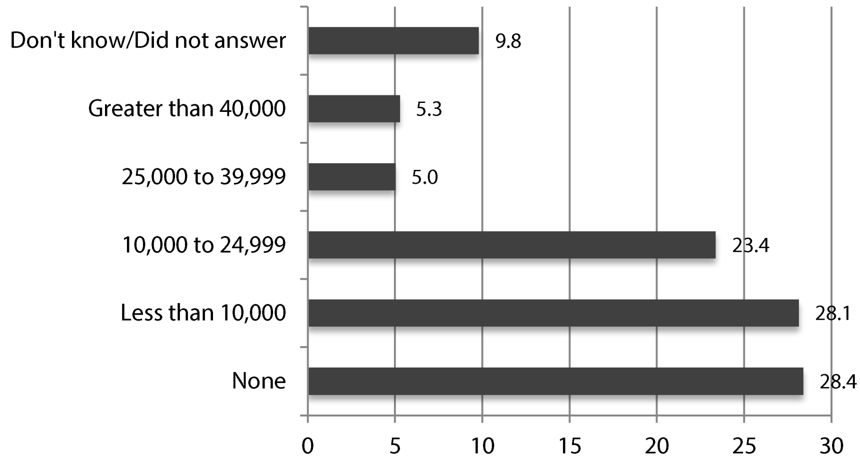

Figure 5. Distribution of HH head respondents by monthly income (in PHP)

4.2 Attitudes on and Perceptions of Air Quality in Baguio City

In general, the HH head respondents have been residing in their respective residences for quite a long period of time—about 29 years. Across locations, Quadrant 1 and Quadrant 2 had a relatively greater proportion of households who were in their respective residences for less than 21 years. The respondents were more familiar with distinguishing the seasons of the year as "cool" and "warm," rather than "dry" or "wet." Most of the respondents rated the air quality in their area of residence to still be "fair" or "good," whether in the "cool" season (November-April), or the "warm" season (May-October).

The air quality in the CBD was perceived to be significantly worse than that in their residential areas. Overall, around 60% of the respondents rated the air quality in the CBD ranging from "poor" (37%) to "very poor" (24%) during the November-April months. This proportion drops to about 50% during the May-October months. Across locations, a lower proportion of the respondents from Quadrant 1 (less than 50%) rated the air quality in the CBD as either "poor" or "very poor".

In general, there was close consensus that air quality in the CBD is poorest in April and May months (Figure 6). These are the "summer vacation" months when local tourists come to Baguio to escape the high temperatures in the lowlands. The identification of April (included in the "cool" season) and May (included in the "warm" season), may yield low contrasts in the perception of the respondents in the differences in air quality during the "cool" and "warm" months. Most of the respondents (89%) agreed that the local government should do something about the air pollution problem in the City.

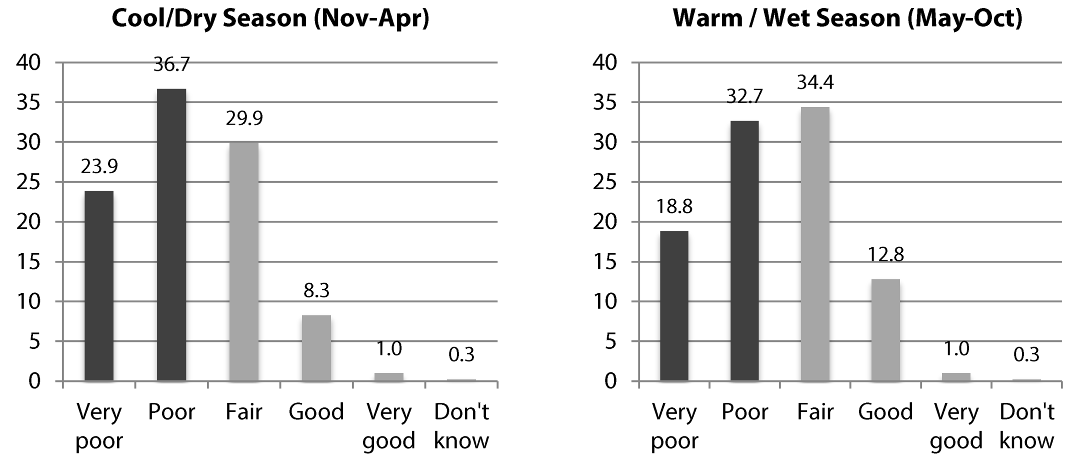

Figure 6. Perceptions of respondents about air quality in Baguio CBD by season

4.3 Exposure of Households to Air Pollution

In general, households did not employ special gadgets in their homes to protect themselves from air pollution. Most simply used handkerchiefs or masks (70%) or closed the windows (53%). This was a consistent behavior since majority of the respondents rated the air quality in their respective residential areas to be somewhere between "fair" and "good."

On average, the distance of the house from a major road was 150 meters (m). The respondents estimated their place of residence to be about less than 1 km from the Baguio CBD. Thus, from the respondents' perception, their residence was located "close" to the CBD, although they could still distinguish the difference in air quality between that of the CBD and their own residential area.

Households used relatively "cleaner" cooking fuel, with around 96% using LPG. Around a third of the households (34%) also used fuel wood/charcoal; these cooking fuel materials may be used as backup when the main cooking fuel runs out. As a whole, half (50%) of the sample households reported the presence of a tobacco smoker in the household. Whereas emissions from motor vehicles constitute "outdoor" air pollution, smoke from tobacco from smokers in the household constitutes "indoor" air pollution.

The air quality where the residential areas were located may be described as "fair" to "good." However, household members who regularly go to work in the CBD would be at risk of being exposed to air quality in the CBD that ranges from being "poor" to "very poor." A high 44% of the households reported to have had members working in the CBD (Figure 7). Across locations, Quadrant 1 households reported higher than average incidence of a member working in the CBD at 59%.

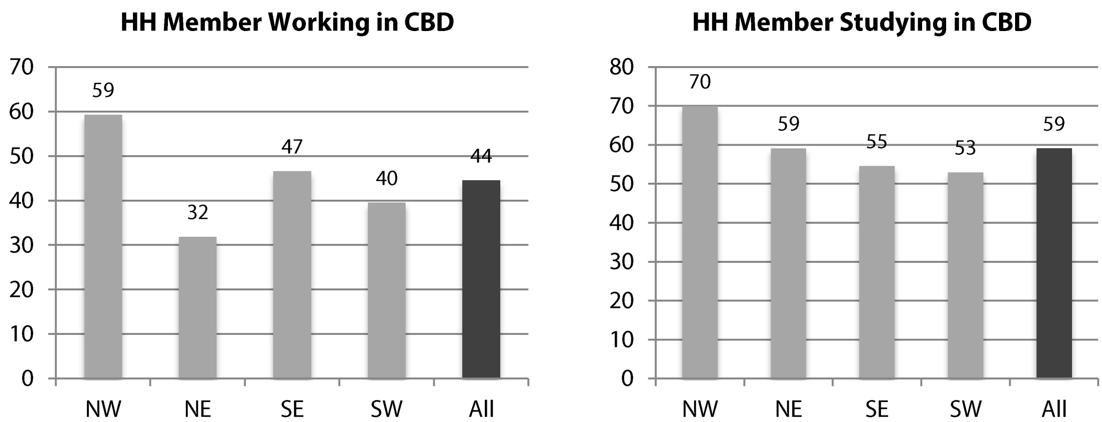

Figure 7. Incidence of household members working or studying in CBD

In a similar manner, household members going to school in the CBD would be at the risk of being exposed to "poor" and "very poor" air quality in the CBD. Close to 60% of the households reported household members going to school in the CBD. Across locations, also Quadrant 1 reported higher than average incidence of household members going to school in the CBD (70%).

4.3.1 Exposure of households to air pollution by mode of transport

The working members used multiple modes of commuting to the CBD. The most popular means was walking to work (73%), followed by taking the PUJ (55%). A significant proportion also took taxis (43%). Close to a third (32%) used private vehicles. The mode of commuting to work or to school in the CBD suggests the varying degrees of exposure to motor vehicle emissions.

Walking along the main roads where vehicular traffic is heavy, particularly during the morning and afternoon rush hours, puts the walkers at a high risk of direct exposure to the motor vehicle emissions. Using the PUJ, which is an "open" vehicle that traverses the main roads leading to the city, also puts the riders at a high risk of direct exposure, not only from the PUJ's own emissions, but from the emissions of vehicles in front of the PUJ or from vehicles on the other lane coming from the opposite direction. Taxi cabs have the potential of being "closed" vehicles. The windows could be raised and the air conditioning turned on as protection against smoke emissions from other vehicles on the road. Taxi cab drivers, however, have their air conditioning units turned off and windows opened as the default mode in order to save on fuel consumption.

One can state that most commuters to the Baguio CBD are directly exposed to emissions from motorized vehicles whatever choice is made among the most popular modes of commuting—walking or taking public transportation.

4.3.2 Respiratory and cardiovascular disease profile of sample households

Incidence, in the context of the survey, refers to the presence of at least one member of the household having been diagnosed, at any time during the last three years (2011–2013), of a specific disease enumerated in the survey.

The general classification of disease with the highest incidence among the sample households was URTI, with an incidence rate of about 65% (Figure 8). Within URTI, the specific diseases classified under this general heading also exhibited relatively high incidence rates, including common cold (49%), pharyngitis/tonsilitis (48%), allergic rhinitis (46%), sinusitis (42%), and laryngo-tracheo-bronchitis (36%). The specific disease with the highest rate of incidence among households was asthma (51%). The rest of the diseases had significantly lower incidence rates than that of URTI or asthma. The next two categories were ALRI (16%) and CVD at 15% (Figure 9). The diseases with very low incidence rates were COPD, tuberculosis, and lung cancer.

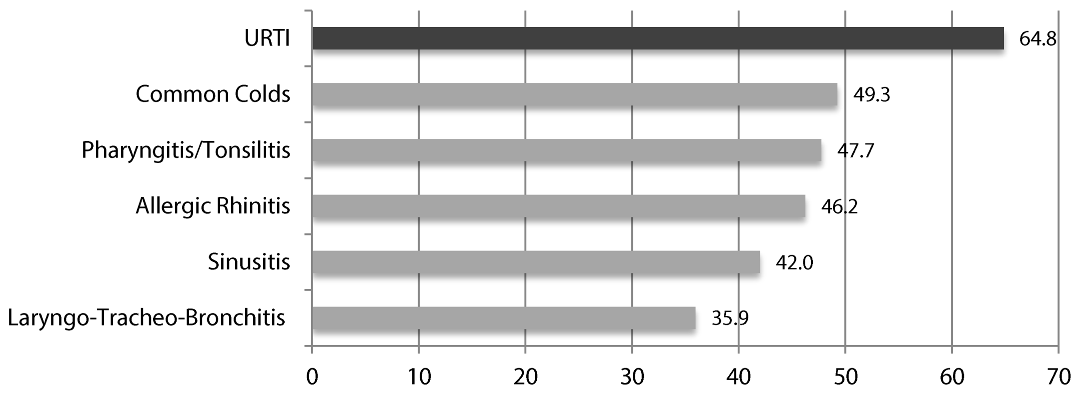

Figure 8. Proportion of HH with Upper Respiratory Tract Infection

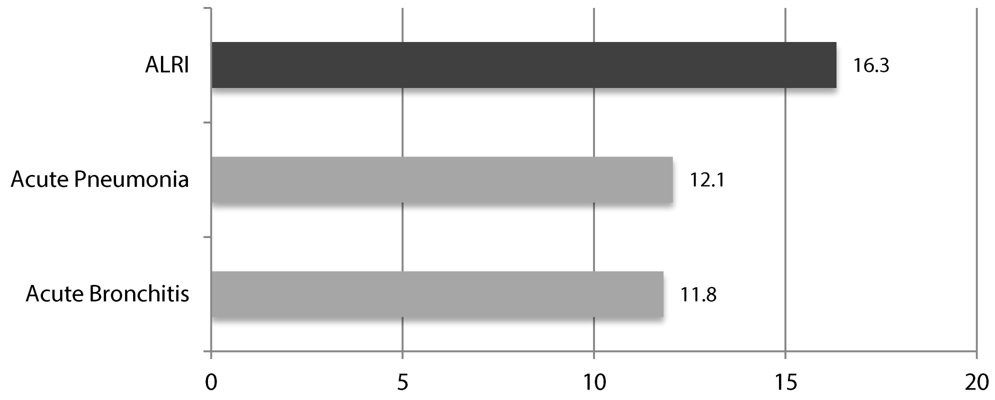

Figure 9. Proportion of HH with Acute Lower Respiratory Tract Infection

4.3.3 Comparison of cardiovascular and respiratory disease incidence rates from Baguio health statistics of 2012 and COI HH survey of 2014

Table 6 compares the rates of incidence of the identified cardiovascular diseases among the entire population using the Baguio Health Department statistics, and the rates of incidence among the population sample obtained from the Project's COI Household Survey.

On the outset, a strict direct comparison could not be made in terms of the true incidence rates since the sampling frames were not the same. Furthermore, the definition of the classes of diseases and the inclusion and exclusion of particular diseases within a class may not be identical. The Baguio Health Department has certain objectives in isolating certain diseases from others within a class of diseases. When there were possible differences in ailments included or excluded within a class, the parallel nomenclatures were given for the COI HH Survey, and were italicized.

Table 6. Comparison of 2012 Baguio City Health Statistics incidence rates of cardiovascular-respiratory diseases and the COI HH Survey of 2014

Baguio Health Statistics Rank	Diseases	Percent of 2012 Baguio Population (%)	Percent of 2014 COI HH Survey Sample (%)
1	Acute respiratory infection/URTI	3.04	30.77
2	ALRI and pneumonia	1.86	3.91
6	Hypertension/CVD	0.73	3.69
8	Bronchitis/COPD	0.65	0.32
10	Asthma	0.39	13.75

Sources: Baguio City Health Department (2014); COI HH Survey (2014)

A point of consistency could be observed in the ranking of the classes of disease, except for the last item (i.e., asthma). Although asthma only ranked 10th in the Baguio Health Department Statistics, the experience of asthma attacks or exacerbations came in second in rank in the COI Household Survey.
One source of discrepancy, however, could be stated. The morbidity rates reported in the Baguio Health Department statistics tend to underestimate the true incidence as they generally referred to cases reported by the public hospital (Baguio General Hospital and Medical Center) and the barangay health clinics. Private hospitals and private clinics are not obliged to report the cases of patients that these health facilities admit.

4.4 Treatment-Seeking Behavior of Households and Patients in the COI HH Survey

Households make decisions on where their sick members will receive treatment.
The treatment-seeking behavior of households and their patients sheds some light into the likely underreporting of the cases of cardiovascular and respiratory diseases. Keeping in mind that the Baguio

Health Department statistics on morbidity captures the information of recorded visits to the public hospital (i.e., BCGH) or to the Baguio main health center or to the barangay health centers, there are cases of morbidity that go unrecorded because other households bring their patients to private clinics or private hospitals. Table 7 shows the relative distribution of cases according to the treatment that the households have chosen for their own patients. It also shows that except in the rare cases of very serious ailments, households do not choose hospital admission as the primary place of treatment. In general, households seek treatment for their patients from health clinics, public or private, or would simply resort to self-medication (i.e., neither seeking hospital admission nor consulting with physicians in public or private health clinics). In particular, for the less serious cases of URTI, most resort to self-medication. Such household- or patient-choice behavior would likely redound to an underreporting of the cases of URTI.

In the summary of computations in the last two rows of Table 7, when the cases of URTI are included, self-medication predominates as the treatment of choice among households. Excluding URTI, however, hospital admissions increase to 15% of the cases. Consultations with physicians outside the hospitals become as frequent a choice as self-medication. Nevertheless, even for non-URTI morbidity cases, more that 40% of cardiovascular and respiratory cases would go unrecorded in the Baguio health statistics.

Table 7. Treatment-seeking behavior of households according to the type of ailment suffered by their patients (in percent within class of ailment)

Disease	Hospital Admission (%)	Outpatient Consultation (%)	Self-Medication (%)
URTI (n = 575)	0.9	22.8	77.0
ALRI			
Acute Bronchitis (n = 40)	10.0	42.5	52.5
Acute Pneumonia (n = 33)	33.3	39.4	45.5
Asthma (n = 257)	13.6	47.9	46.7
COPD			
Chronic Bronchitis (n = 3)	33.3	66.7	33.3
Emphysema (n = 3)	33.3	33.3	66.7
Tuberculosis (n = 5)	40.0	100.0	0.0
Lung Cancer (n = 1)	100.0	100.0	0.0
Cardiovascular Disease (n = 69)	20.3	47.8	49.3
All cases	7.1	31.5	61.4
All cases except URTI	15.1	42.7	42.2

Sources: Baguio City Health Department (2014); COI HH Survey (2014)

4.4.1 Cost of illness: Direct and indirect costs of illness per affected individual at the household level

The occurrence of illness in the household entails direct and indirect costs. In this study, the direct costs included expenses for hospitalization, doctor's fees, medications, and other direct expenses for the treatment of the patient. The indirect costs were limited to the value of reduced activity days (RAD) when the patient was confined in the hospital or recuperated at home, and when a caregiver needed to take some days off to attend to the patient in the hospital or at home. Furthermore, the value imputed to the RAD was limited to the foregone earnings of the patient and the caregiver. When the patient and the caregiver were currently employed individuals, the opportunity cost of foregone income per day was valued at the minimum daily wage in the locality (PHP 280). When the patient and the caregiver were not currently employed but were of employment age (15–65 years), the opportunity cost of foregone income per day was set at 75% of the minimum daily wage (PHP 210).

Direct costs. Table 8 shows the configuration of the mean values of the direct cost of illness per affected individual according to cost categories, by type of illness. In general, hospitalization costs dominated other costs. Except for emphysema, and in the cases where the hospitalization costs were not reported by the respondents (chronic bronchitis and tuberculosis), medications accounted for the largest component.

Table 8. Direct costs of illness per affected individual (in PHP)

Disease	Hospital Fees	Doctor's Fees	Medications	Others
URTI (n = 575)	22,000	573	711	11,384
ALRI				
Acute Bronchitis (n = 40)	29,667	1,054	1,032	1,955
Acute Pneumonia (n = 33)	22,387	588	5,570	2,158
Asthma (n = 257)	23,907	567	2,945	2,980
COPD				
Chronic Bronchitis (n = 3)	n/a	1,008	7,200	3,333
Emphysema (n = 3)	25,000	512	56,940	n/a
Tuberculosis (n = 5)	n/a	5,440	23,731	n/a
Lung Cancer (n = 1)	140,000	74,000	74,095	n/a
Cardiovascular Disease (n = 69)	35,773	2,433	29,095	n/a

Sources: Baguio City Health Department (2014); COI HH Survey (2014)

Cost of reduced activity days. The RAD of the patient and of the caregiver over the period of the patient's treatment was also obtained. In both the patient and the caregiver, information was extracted on whether they were currently employed or not. If not, their ages were determined to classify them as to whether they were within the "employment age" or not. Table 9 presents the number of RAD that each of the patient and the caregiver incurred while the patient was undergoing treatment, either at the hospital or at home. In most cases, where RADs were incurred, the number of days lost to work (or potential work) ranged from one to three days. The higher-than-three days were observed for acute pneumonia, asthma, lung cancer, and cardiovascular disease. Note that in many of the cases and disease classifications, the respondents did not report the number of days of inactivity that either the patient or the caregiver had incurred. The large incidence of "non-reporting" had a significant deflationary impact on the estimation of the mean values of RAD when averaged for all respondents.

Table 9. Average reduced activity days (RAD) per affected individual

Disease	Patient		Caregiver	
	Employed	Employable	Employed	Employable
URTI (n = 575)	2.32	1.90	2.00	1.00
ALRI				
Acute Bronchitis (n = 40)	1.00	2.50	n/a	n/a
Acute Pneumonia (n = 33)	8.33	0.50	n/a	n/a
Asthma (n = 257)	4.91	2.00	3.17	2.50
COPD				
Chronic Bronchitis (n = 3)	n/a	n/a	n/a	n/a
Emphysema (n = 3)	n/a	n/a	n/a	n/a
Tuberculosis (n = 5)	n/a	n/a	n/a	n/a
Lung Cancer (n=1)	89.00	n/a	7.00	n/a
Cardiovascular Disease (n = 69)	2.00	6.00	n/a	n/a

Sources: Baguio City Health Department (2014); COI HH Survey (2014)

The average value of RAD of each individual for each type of illness is shown in Table 10. In patients, the RADs were not recorded if the patient was a child (neither employed nor employable), so that no value was imputed on the foregone income. Caregivers, however, would generally be employed or employable. The non-reporting of their RAD was traced to their not being able to recall the approximate numbers.

In affected patients, the values of the RAD were relatively high for lung cancer, acute pneumonia, asthma, and cardiovascular disease. In caregivers, the higher values of the RAD were observed in asthma and lung cancer.

Table 10. Average value of reduced activity days (RAD) per affected individual (in PHP)

Disease	Patient		Caregiver	
	Employed	Employable	Employed	Employable
URTI (n = 575)	650	399	560	210
ALRI				
Acute Bronchitis (n = 40)	280	525	n/a	n/a
Acute Pneumonia (n = 33)	2,332	105	n/a	n/a
Asthma (n = 257)	1,375	420	888	525
COPD				
Chronic Bronchitis (n = 3)	n/a	n/a	n/a	n/a
Emphysema (n = 3)	n/a	n/a	n/a	n/a
Tuberculosis (n = 5)	n/a	n/a	n/a	n/a
Lung Cancer (n = 1)	24,920	n/a	1,960	n/a
Cardiovascular Disease (n = 69)	560	1,260	n/a	n/a

Sources: Baguio City Health Department (2014); COI HH Survey (2014)

Average cost of illness. The COI estimates included both direct and indirect costs. Table 11 shows the average cost of illness per affected individual. Across types of illnesses, affected individuals incurred the highest cost when affected by lung cancer. Note that there was only a single case observed for this disease. The two other high-cost diseases were emphysema and cardiovascular disease, in that order. These were followed by tuberculosis and acute pneumonia, respectively. As expected, URTI entailed the least cost of illness. It could also be observed that the direct costs of illness dominated the indirect costs, consistently comprising higher than 90% of total cost. As previously observed, this may stem from the non-reporting of respondents of their estimates of patients' and caregivers' RADs.

Table 11. Average cost of illness per affected individual (in PHP)

Disease	Direct Costs (PHP)	Indirect Costs (PHP)	Total (PHP)	Share of Direct Costs (%)
URTI (n = 575)	3,041	121	3,162	96.2
ALRI				
Acute Bronchitis (n = 40)	5,084	283	5,367	94.7
Acute Pneumonia (n = 33)	10,655	504	11,159	95.5
Asthma (n = 257)	6,606	328	6,934	95.3
COPD				
Chronic Bronchitis (n = 3)	6,742	700	7,442	90.6
Emphysema (n = 3)	41,482	–	41,482	100.0
Tuberculosis (n = 5)	16,399	–	16,399	100.0
Lung Cancer (n = 1)	288,095	29,645	317,740	90.7
Cardiovascular Disease (n = 69)	34,181	33	34,214	99.9

Sources: Baguio City Health Department (2014); COI HH Survey (2014)

4.5 Estimates of Morbidity and Mortality Outcomes in Baguio City[1]

The Martuzzi et al. (2002) values for the RR coefficients were adopted and applied to the identified health outcomes for the available data on mortality rates and morbidity rates, refined and differentiated across age groups, where city-level public health statistical data were available. The application of the RR coefficients was direct when the associated health statistics data were existent and available.

Using the available statistical data on Baguio City mortality and morbidity numbers and rates of incidence, the same RR coefficients could not be applied directly due to the following reasons:

1. The data on hospital admissions were not readily obtainable for the health outcomes defined in terms of hospital admissions.

[1] Application of the Martuzzi et al. (2002) RR coefficients.

2. Admissions in the private hospitals were not necessarily reported and recorded in the public statistics.
3. Even if data on hospital admissions for the identified illnesses could be obtained, the numbers of hospital admissions would understate the incidence of the health outcome, as was demonstrated in the treatment-seeking behavior of households with members afflicted with cardiovascular and or respiratory diseases.
4. The definition of the health outcome with the associated RR coefficient may not be exactly identical to how the health outcome has been described at the local level statistics.

Nevertheless, as the Martuzzi et al. (2002) RR estimates of PM_{10} exposure have been carefully culled from the vast sources in the epidemiology literature, these same coefficients could be adopted, but with the caveat that there would be some degrees of uncertainty if the central estimates are used. The CIs (i.e., 95%) of the central estimates would at least cover the wide range at which the true values at the local (Baguio City) levels would likely fall. Table 12 attempts to make parallel health outcomes described in the Baguio City Health Department statistics on mortality and morbidity with those outcome used by Martuzzi et al. (2002).

Table 12. Parallel cardiovascular and respiratory health outcomes, Baguio City Health Department

Martuzzi et al. (2002) Health Outcomes	RR Central Estimate	AF per 10 μg/m^3 in PM_{10}	Parallel Baguio Health Department Description
Adult mortality (30+)	1.026	0.0253	Adult Mortality (30+)
Hospital admissions for CVD	1.009	0.0089	Hypertension
Hospital admissions for respiratory disease	1.016	0.0157	ALRI
Acute bronchitis in children (<15)	1.306	0.2343	Bronchitis (< 15 years)
Asthma exacerbation (Children <15)	1.051	0.0485	Asthma (<15 years)
Asthma exacerbation (Adults 20+)	1.004	0.0040	Asthma (20+ years)
Occurrence of respiratory symptoms	1.070	0.0654	URTI

Sources: Martuzzi, et al. (2002); Baguio City Health Department (2014)

The PM_{10} readings represent the concentration levels within the CBD where most of the economic activity, offices, and schools are located. There are three other EMB-CAR monitoring stations outside Baguio CBD (e.g., Camp John Hay area, Baguio Country Club area, Wright Park area), but they represent parks and recreation areas where tourists frequently go to; thus, they do not represent the PM_{10} levels that Baguio constituents or residents are constantly exposed to.

4.5.1 Demographic structure of mortality and morbidity numbers

The estimation of the magnitude of the health outcomes from increased levels of exposure to PM_{10} done in this research followed the estimation done by Martuzzi et al. (2002) in order to establish the basic demographic structure of mortality and morbidity incidence and the relevant exposed population. Table 13 establishes the basic information at the local level Baguio City.

Table 13. Basic population, mortality and morbidity cases, and incidence rates in Baguio City

Health Outcome	No. of Cases	Relevant Exposed Population	Observed Incidence Rate
Nontraumatic adult mortality (30+)	1,145	134,249	0.0085
Hypertension	2,364	345,400	0.0068
ALRI	4,292	345,400	0.0124
Bronchitis (< 15 years)	1,212	96,722	0.0125
Asthma (<15 years)	660	96,722	0.0068
Asthma (20+ years)	553	211,151	0.0026
URTI	12,089	345,400	0.0350

Source of basic data: Baguio City Health Department (2014)

Only the cases of nontraumatic mortality were included in the incidence rates (Table 13) following the definition of adult mortality found in the literature. To calculate the observed incidence rates in the specific health outcomes, the relevant population had to be established. If the outcomes were defined on particular age groups, then the number of cases and the population of the age group had to be isolated. It was assumed in the base case that the entire population was exposed to the same concentration level of PM_{10}, which was computed at the mean annual level recorded at Baguio CBD at 83.2 μg/m^3. The magnitude of health outcomes due to PM_{10} exposure was expected to be lower when only a fraction of the relevant population was assumed to be exposed to the Baguio CBD PM_{10} concentration levels (Table 13).

4.5.2 Health outcomes attributable to PM_{10} exposure exceeding the WHO long-term health guideline of 20 μg/m^3

Estimating the number of cases of specific health outcomes due to exposure to elevated levels of PM_{10} that are beyond the defined base levels needs to use data on actual PM_{10} levels and its distance from the target level. Similarly, data on RR coefficients for every 10 μg/m^3 increment PM_{10} established in the epidemiological literature were also used in order to derive AF. The base rates of incidence (*B*) at base (target) PM_{10} were derived from the data on the observed mortality or morbidity incidence rates. The derived base incidence rates are to be interpreted as the associated mortality or morbidity incidence rates that would have occurred had the PM_{10} levels been kept at the base (target) levels. They should not be interpreted as the incidence rates that would have prevailed had there been zero PM_{10}, or no pollution, at all.

For purposes of discussion, if the base level for PM_{10} was set to zero (unrealistically, of course), then the resulting base rates of incidence would indicate that the mortality and morbidity outcomes would still occur although it would be due to causes other than exposure to PM_{10} pollution (e.g., to other triggers of the identified health outcomes).

Table 14 shows the results for the number of attributable cases of the respective mortality and morbidity outcomes at base PM_{10} exposure of 20 μg/m^3. As expected, the results on the base incidence rates show that mortality and morbidity rates of incidence would have been lower had the PM_{10} concentrations to which the relevant population was exposed to were at levels matching the WHO long-term guideline.

The results on the attributable cases of nontraumatic deaths of 157 should be interpreted as the number of deaths that would have been avoided had the actual levels of population exposure to PM_{10} been as low as to have met the WHO Guideline of PM_{10} = 20 μg/m^3, rather than the long-term actual mean of 83.2 μg/m^3. Relative to the actual number of nontraumatic deaths in 2013, the number of preventable deaths translates to about a 14% reduction in the number of cases. Note that the results on the attributable cases for bronchitis in children (< 15 years) were estimated at 612 cases. This constitutes a very high 50.5% of the total. This stems from the high RR coefficient established in the epidemiological literature on the impact of various levels of exposure to PM_{10} on children, as manifested in the changes in the incidence of bronchitis.

Also noteworthy is the relative magnitude of the impact of exposure to elevated levels of PM_{10} on asthma exacerbation in children (< 15 years). The attributable cases for children constitute close to a quarter of the total.

Finally, the relative magnitude of exposure to high levels of PM_{10} on upper respiratory ailments was also high, with the attributable cases accounting for around 29% of the total. The health outcomes of setting the PM_{10} target at 60 μg/m^3 (in line with the Philippine CAA of 1999) are presented in Table 15.

In this scenario, the figures under the attributable cases could be interpreted as the annual numbers of nontraumatic premature mortalities and the number of specific morbidity cases that could have been avoided if the PM_{10} concentration levels had been reduced by policy measures and instruments from 83.2 μg/m^3 to 60 μg/m^3, as prescribed by the Philippine Clean Air Act of 1999. While nominally, the mortality and morbidity numbers of "saved" cases are not significant, these figures could be compared to the number of mortality and morbidity cases that could be avoided if public policy pursued measures and instruments that would drive the PM_{10} concentration levels all the way down to the WHO AQG for the pollutant. Such a comparison would show that if the WHO AQG were relentlessly pursued, then the number of attributable mortality and morbidity cases that could be avoided would more than double those achievable under the pursuit of a less stringent standard.

Table 14. Health outcomes attributable to exposure to long-term mean level of PM_{10} at 83.2 μg/m^3 using the WHO guideline of PM_{10} at 20 μg/m^3 as background level

Health Outcome	Actual Cases	Actual Incidence Rate	Base Incidence Rate at PM10 = 20 μg/m^3	Attributable Cases	Attributable Percentage (%)
Nontraumatic adult mortality (30+)	1,145	0.0085	0.0073	157	13.8
Hypertension	2,364	0.0068	0.0065	126	5.3
ALRI	4,292	0.0124	0.0113	388	9.0
Bronchitis (< 15 years)	1,212	0.0125	0.0043	612	50.5
Asthma (<15 years)	660	0.0068	0.0052	153	23.2
Asthma (20+ years)	553	0.0026	0.0026	14	2.5
URTI	12,096	0.0350	0.0243	3,465	28.6

Sources: Baguio Health Department, 2014; Martuzzi et al. (2002)

Table 15. Health outcomes of setting the PM_{10} target at 60 μg/m^3 in line with the Philippine CAA of 1999

Health Outcome	Actual Cases 2013	Actual Incidence Rate	Base Incidence Rate at PM10 = 20 μg/m^3	Attributable Cases	Attributable Percentage (%)
Nontraumatic adult mortality (30+)	1,145	0.0085	0.0080	63	5.5
Hypertension	2,364	0.0068	0.0067	48	2.0
ALRI	4,292	0.0124	0.0120	151	3.5
Bronchitis (< 15 years)	1,212	0.0125	0.0073	385	31.8
Asthma (<15 years)	660	0.0068	0.0061	66	10.1
Asthma (20+ years)	553	0.0026	0.0026	5	0.9
URTI	12,089	0.0350	0.0301	1,578	13.0

Sources: Martuzzi et al. (2002); Baguio Health Department (2014)

This is significant when crafting local (and even national) public policy that prescribes how to design measures that would reduce the concentration levels of air pollution. Setting standards or targets that are relatively lenient would tend to make policy makers complacent in their efforts to reduce air pollution concentration levels in their own constituencies. When such lenient standards become the "norm," they give a false sense of looking at the current concentration levels as "not being very far off" from what is mandated by the law. The danger is that what is defined by the law as "acceptable" level of PM_{10} pollution concentration does not, in any way, reduce the health risk levels that the affected population is exposed to at the current concentration levels.

The WHO sets AQG for PM_{10} at 20 μg/m^3, and also sets graduated "temporary" or "interim targets" (IT) that the national and local governments can refer to. Over time, they should commit to undertake measures progressively that would eventually aim for the WHO AQG. For long-term PM_{10} concentration levels, the first IT (IT-1) is set at 70 μg/m^3; the second (IT-2) is set at 50 μg/m^3; and the third (IT-3) is set at 30 μg/m^3.

ITs can by no means be interpreted as "permanent." Since the enactment of the Philippine CAA in 1999 more than 15 years ago, the national standard for long-term PM_{10} has not moved at 60 μg/m^3. This standard has not progressed to even approach the IT-2 of the WHO guidelines.

4.6 Economic Value of the Mortality and Morbidity Outcomes Attributable to Exposure to Elevated Levels of Air Pollution

4.6.1 Cost of premature mortality

The economic value of nontraumatic deaths attributed to elevated levels of air pollution was evaluated in this study using the opportunity cost of lost years of productive life due to premature mortality of adults aged 30 years and above. The average life expectancy of Filipinos for the period 2010–2015 was set at 70 years (68 years for males and 73 years for females) by the Department of Health. This figure is projected to rise to 75 years for 2030–2035 (DOH 2011). Lost years of remaining productive life, however, is computed up to only 65 years for premature adult mortality. The attributed deaths are also grouped according to the age grouping of total premature adult deaths.

In this study, the minimum wage of PHP 280 per day for CAR was adopted as the opportunity cost per day. A five-day work week and a 50-week working year were assumed. The unemployment rate in CAR was estimated at 6.5%. The unemployed individuals were assumed to be generating no income. Furthermore, the underemployment rate was estimated at 14.5%. Their income was assumed to be just 50% of the mean income of the fully employed. After the adjustments for unemployment and underemployment rates were done, which were assumed to remain constant in the future, the aggregate foregone income of the attributable deaths across age groups was estimated to be PHP 53,332,408 per year from 2013 onward. This assumes that the attributable deaths would remain at 157 deaths per year, without interventions toward reduction of the PM_{10} mean concentration levels of 83.2 μg/m^3. On a straight per capita estimation of the opportunity cost of premature mortality for all 157 cases, the estimate was pegged at PHP 339,697 at the mean for each individual.

4.6.2 Cost of illness of air pollution-related attributed deaths and morbidity

The direct costs of illness were obtained using the mean cost per capita of hospitalization, outpatient consultations, and medicines for treatment of each particular health outcome estimated in the COI Household Survey of 2014. Table 16 shows the health outcome-specific costs per capita and the aggregate of all attributable cases.

The results shown in Table 16 indicate that the cost of premature mortality dominates (PHP 53.33 million per year), which accounts for 69% of total costs. The remaining 31% is attributed to the direct costs to patients of hospital admission, outpatient consultations, and per year of medications for treatment (PHP 24.04 million per year). Thus, the aggregate direct cost of premature mortality and illness attributable to PM_{10} exposure in Baguio City was estimated to be about PHP 77.37 million per year.

Table 16. Per capita and aggregate directs costs of premature mortality and illness attributable to PM_{10} exposure, Baguio City (in PHP per year)

Health Outcome	Attributable Cases	Cost per Capita (PHP)	Aggregate Cost per Year (PHP)
Mortality Costs			
Nontraumatic adult mortality (30+)	157	339,697	53,332,408
Morbidity Costs			
Hypertension/Cardiovascular disease	126	34,214	4,314,138
ALRI	388	11,159	4,329,061
Bronchitis (< 15 years)	612	5,367	3,283,079
Asthma (<15 years)	153	6,934	1,061,392
Asthma (20+ years)	14	6,934	94,169
URTI	3,465	3,162	10,957,157
Total COI per year			24,038,996
Total opportunity cost of premature adult mortality per year			53,332,408
Total direct costs per year			77,371,404

Sources: COI HH Survey 2014; DOH (2014a); DOLE (2014)

Under COI, the cost of treatment per capita of URTI cases was the lowest. In the aggregate, however, it constituted the largest value (PHP 10.96 million per year). This arises from the fact that these milder symptoms were the most frequently experienced, registering the highest incidence rates in the city among all leading causes of morbidity. This health outcome constituted around 46% of the aggregate COI. The two health outcomes that followed in terms of contribution to aggregate costs were ALRI and cardiovascular diseases or hypertension, which accounted for about 18% each of the aggregate. There is contrast in these two health outcomes: although cardiovascular diseases had higher costs per capita, the attributable cases were smaller (less than half) than those of ALRI cases.

Finally, the joint costs of the health outcomes on children less than 15 years of age (bronchitis and asthma) were about the same level as the ALRI aggregate costs.

5.0 CONCLUSIONS AND AREAS FOR FUTURE RESEARCH

Objectively, the long-term mean concentration levels of air pollution in Baguio CBD (measured in $\mu g/m^3$ of the pollutant PM_{10}), exceed the national and international health standards. The long-term mean PM_{10} at 83.2 $\mu g/m^3$ over a six-year period (2007–2012) exceeded the long-term standard of 60 $\mu g/m^3$ of the Philippines Clean Air Act of 1999 by close to 40%, and was more than four times higher than that of the WHO air quality guideline (AQG) for PM_{10} at 20 $\mu g/m^3$. Subjectively, majority of the households residing within the 1.5-kilometer radius from Baguio CBD perceived the air quality of the CBD as either "very poor" or "poor." Furthermore, majority of these households asserted that the local government officials should undertake measures that would reduce the air pollution concentration levels in the CBD.

Majority of the household respondents had members that regularly commute to the CBD for work or for schooling, with most of them either walking or taking the diesel-powered PUJ, which was the most popular mode of public transport. This implies that most households had members that are daily exposed to the high concentration levels of PM_{10} in the CBD, while at work, or while at school.

In general, the rate of incidence of the identified air pollution-related illnesses in the sample households was significantly higher than that in the Baguio City Health Statistics. This confirms the assertion that the morbidity rates reported in the Baguio Health Statistics are understated, as only cases reported by the public hospital and barangay health centers enter into the records. Cases treated in the private hospitals and clinics are not generally recorded.

Although the household survey confirmed that URTI were the most prevalent of illnesses among the population, the prevalence of asthma was also very high, being the second most common illness; in the Baguio Health Statistics, asthma ranked only 10th in the leading causes of morbidity.

The cost of illness to individuals and households depends, among others, on the household's treatment-seeking behavior. Only a very low proportion of individuals who had become ill due to cardiovascular or respiratory ailments availed of treatment at a hospital. The majority either consulted with a physician or simply resorted to self-medication. This pattern of behavior reveals that in poorer economies or societies where universal access to health services is not the norm, the statistics on the cases of hospital admissions would grossly understate the incidence of air pollution-related illnesses.

Relative to their total incomes, households do incur a heavy burden when a member falls ill to an air pollution-related disease. On a per person basis, cardiovascular ailments entailed the highest expenditures while URTI entailed the least. The second most costly group of illnesses to treat was ALRI.

The standard formula for estimating the attributable cases of mortality and morbidity associated with exposure to the current levels of PM_{10} were applied in this study by

1. adopting the RR coefficients that are based on the epidemiological literature regarding particular health outcomes for each 10 $\mu g/m^3$ increase in PM_{10} concentration levels in the ambient air,
2. adopting the WHO AQG for PM_{10} as the long-term health standard, and
3. taking the long-term mean concentration level at Baguio CBD as the actual level to which the population is exposed to.

The results of the number of attributable cases, reckoned on an annual basis, cannot be ignored. Specifically, the results showed that the proportion of attributable cases according to specific health outcomes was highest in children aged 15 years and below. These findings revealed that children were most prone to the adverse health effects of exposure to high concentration levels of PM_{10}. In this age group, about half of the cases of bronchitis and close to a quarter of the cases of asthma were estimated to be due to PM_{10} exposure. Even using the lower bound for the 95% CI of the RR coefficients for the health outcomes for bronchitis and asthma in children, the proportion of attributable cases remained high at 41% for bronchitis and 22% for asthma.

More than 15 years after the Philippine Clean Air Act of 1999 has been enacted, the long-term PM_{10} national standard has remained static at 60 $\mu g/m^3$. A policy that would only aim to lower the PM_{10} concentration levels in the Baguio CBD to conform only to the national standard for long-term PM_{10} critical level set at 60 $\mu g/m^3$—rather than to the WHO AQG of 20 $\mu g/m^3$—would result in reducing the attributable cases of premature nontraumatic mortality by only about 40%, and would result in reducing attributable cases of cardiovascular and respiratory illnesses by about 47%. This implies that policy measures that reduce long-term PM_{10} concentration levels all the way down to the WHO AQG level would have the impact of more than doubling the reduction in attributable cases of mortality and morbidity over those that could be achieved by stopping at the set national standard.

The WHO sets graduated "temporary" or "interim" targets (IT) for PM_{10} concentration levels. The national and local governments should therefore aim for these until the AQG of 20 $\mu g/m^3$ is achieved. ITs are associated with gradually lower risks of deaths and illnesses attributable to PM_{10} exposure. The first-level target (IT1) is set at 70 $\mu g/m^3$, the second (IT2) is set at 50 $\mu g/m^3$, and the third (IT3) is set at 30 $\mu g/m^3$. The long-term mean level of PM_{10} in the Baguio CBD does not even meet the WHO IT1.

The annual economic value of the magnitudes of reduction in attributable cases of premature nontraumatic deaths and morbidity from cardiovascular-respiratory cases will be significant if policies and measures that would bring down the long-term PM_{10} concentration levels in the Baguio CBD to a level that meets the WHO health guideline will be implemented. For premature deaths avoided, the economic value that could be saved was estimated to be about PHP 53.3 million per annum. For attributable morbidity cases avoided, the monetary value that could be saved was estimated at PHP 24.0 million per annum.

The PM_{10} concentration levels in Baguio CBD, however, cannot be brought down significantly without a radical change in the type of public mass transport system available to the general public. For decades, the diesel-powered PUJs and taxis were the only public transport modes available.

6.0 LIMITATIONS OF THE STUDY

Ideally, $PM_{2.5}$ is the more preferred measure of concentration level for predicting the particular adverse health impacts of air pollution. $PM_{2.5}$, which measures the more dangerous fine particulates of less than 2.5 micrometers in aerodynamic diameter, is more effective than PM_{10} as this involves only the coarse particulates measuring less than 10 micrometers in aerodynamic diameter. However, only historical data on PM_{10} was available for the city and for the particular location in Baguio CBD. For this reason, the health risk coefficients for PM_{10} associated with mortalities and particular cardiovascular and respiratory illnesses in the epidemiology literature were adopted in this study.

Measured PM_{10} contains $PM_{2.5}$, but the relative importance of the finer particulates and the particular relationship with the measured coarser particulates is unknown. When the EMB-CAR finally set up a $PM_{2.5}$ monitoring machine in the city in May 2014, it was not possible to obtain long-term (annual) concentration levels of the pollutant to make observations about the chronic exposure of the population to the pollutant. Furthermore, EMB set up the $PM_{2.5}$ monitoring machine in a different location as that of the PM_{10} monitoring machine, which is at the Baguio CBD. The $PM_{2.5}$ monitoring station was established at the Burnham Park (Lake), where the main public transport vehicles (i.e., the PUJs) do not traverse.
This monitoring station also has its own PM_{10} machine. The PM_{10} readings, however, cannot be taken to represent those at the Baguio CBD. So far, it can be stated that the $PM_{2.5}$ and PM_{10} data over a 13-month period, on a monthly mean basis, move in the same direction. In general, $PM_{2.5}$ movements "mimic" that of PM_{10}. At the mean, the ratio of $PM_{2.5}$ to PM_{10} concentrations is 0.67. This relatively high ratio is consistent with the assertion that the main generator of particulates, as measured by PM_{10} in the locality, are the motor vehicles rather than from dust particles from nearby construction activities.

The study did not explicitly consider the independent adverse health impacts of the incidence of tobacco smoking among the population exposed to air pollution. Tobacco smoking is known to be associated with particular health risks that are also cardiovascular and respiratory in nature. The study also did not explicitly consider the adverse health impacts of households using fuelwood or charcoal for cooking food. The household survey, nevertheless, obtained information on these aspects of household behavior to temper the interpretation on the quantitative values obtained in estimating health impacts expressed in terms of incidence of particular health outcomes.

The epidemiology literature on the health impacts of exposure to outdoor air pollution, and the resulting health risk coefficients reported, exclude exposure to indoor air pollution, as well as exposure to tobacco smoke. The health outcomes associated with indoor air pollution are studied separately, and the health risk coefficients are estimated differently. In the Philippines study for the World Bank, Arcenas (2009) used the model used by Martuzzi et al. (2002) to measure only the impacts of outdoor air pollution. The author made separate estimates and different health risk coefficients for exposure to indoor air pollution from cooking fuel. He made no separate estimates for the health impacts of tobacco smoking.

In the study's household survey, half of the households had a tobacco smoker in the household. Thus, there are important health outcomes for these households where a tobacco smoker is present, but this study did not pursue the extent to which these outcomes could be quantified.

On the possible health impacts of indoor health pollution, the household survey indicated that 96% of the households used LPG as cooking fuel. Thus, in general, households do not use cooking fuel that emits particulate matter. However, as the responses on cooking fuel used were not exclusive, a third of the households also used fuelwood or charcoal. The frequency of the use of fuelwood or charcoal over a given time period, relative to that of LPG use, was not pursued. What was asserted was that, in general, households used LPG for cooking. However, when LPG in the tank is suddenly exhausted in the middle of the cooking chores, and there is no ready full tank of LPG as replacement, some of the households have fuelwood or charcoal as stand-by, until the replacement LPG tank arrives.

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APPENDICES

Appendix 1. Top Leading Causes of Morbidity and Mortality in Baguio City 2013

Appendix Table 1. Top leading causes of morbidity and mortality, Baguio City, 1st semester, 2013

TOP TEN LEADING CAUSES OF MORBIDITY				
Diseases	Semi-Annual (Jan. to June) - 2013			
	MALE	FEMALE	TOTAL	R/100,000
UPPER RESPIRATORY INFECTION	2,401	2,837	5,238	1516.50
DOG BITE	796	1,174	1,970	570.35
PNEUMONIA	839	803	1,642	475.39
DIARRHEA/ AGE	724	670	1,394	403.59
HYPERTENSION	367	720	1,087	314.71
SYSTEMIC VIRAL INFECTION	419	326	745	215.69
DERMATITIS	283	347	630	182.40
BRONCHITIS	322	302	624	180.66
ASTHMA	304	306	610	176.61
INFLUENZA-LIKE-ILLNESS	311	218	529	153.16
Sub-Total	6,766	7,703	14,469	

Source: Baguio City Health Department

TOP TEN LEADING CAUSES OF MORTALITY				
UMBRELLA CAUSE OF DEATH	Semi-Annual (Jan. to June) – 2013			
	MALE	FEMALE	TOTAL	R/100,000
VASCULAR DISEASE	141	86	227	65.721
CANCER	87	76	163	47.192
HEART DISEASE	80	60	140	40.533
PNEUMONIA	63	49	112	32.426
ACCIDENT AND TRAUMA	62	14	76	22.003
DIABETIS MELLITUS	34	29	63	18.240
KIDNEY DISEASE	23	18	41	11.870
LIVER DISEASE	19	6	25	7.238
PREMATURITY	7	10	17	4.922
COPD	11	3	14	4.053
SEPSIS	11	3	14	4.053
Sub-totals	538	354	892	

Source: Baguio City Health Department

Diseases	Semi-Annual (Jan. to June) - 2013			
	MALE	FEMALE	TOTAL	R/100,000
UPPER RESPIRATORY INFECTION	35.5	36.8	36.20	1516.50
DOG BITE	11.8	15.2	13.62	570.35
PNEUMONIA	12.4	10.4	11.35	475.39
DIARRHEA/ AGE	10.7	8.7	9.63	403.59
HYPERTENSION	5.4	9.3	7.51	314.71
SYSTEMIC VIRAL INFECTION	6.2	4.2	5.15	215.69
DERMATITIS	4.2	4.5	4.35	182.40
BRONCHITIS	4.8	3.9	4.31	180.66
ASTHMA	4.5	4.0	4.22	176.61
INFLUENZA-LIKE-ILLNESS	4.6	2.8	3.66	153.16
Sub-Total	100	100	100	

Source: Baguio City Health Department

TOP TEN LEADING CAUSES OF MORTALITY				
UMBRELLA CAUSE OF DEATH	Semi-Annual (Jan. to June) – 2013			
	MALE	FEMALE	TOTAL	R/100,000
VASCULAR DISEASE	26.2	24.3	25.4	65.721
CANCER	16.2	21.5	18.3	47.192
HEART DISEASE	14.9	16.9	15.7	40.533
PNEUMONIA	11.7	13.8	12.6	32.426
ACCIDENT AND TRAUMA	11.5	4.0	8.5	22.003
DIABETES MELLITUS	6.3	8.2	7.1	18.240
KIDNEY DISEASE	4.3	5.1	4.6	11.870
LIVER DISEASE	3.5	1.7	2.8	7.238
PREMATURITY	1.3	2.8	1.9	4.922
COPD	2.0	0.8	1.6	4.053
SEPSIS	2.0	0.8	1.6	4.053
	100.0	100.0	100.0	

Source: Baguio City Health Department

Appendix 2. Key Informant Interview Instrument for Doctors

2.1 Cardiopulmonary Specialists

2.1.1 Economic Burden of Disease (EBD)

Mortality and morbidity attributable to outdoor air pollution air pollutants generated by motor vehicles with known concentration levels (in μg/m^3) in Baguio City Central Business District

- CO
- CO_2
- NO
- SO_x
- PM_{10}
- $PM_{2.5}$

2.1.2 Focus: PM_{10} and $PM_{2.5}$

1. *Epidemiological literature (global):* statistically robust *causal relationship* between concentration levels of these pollutants and the incidence of mortality and morbidity due to cardio-respiratory illnesses attributable to them
2. *Air pollution literature:* positive correlation between levels of PM_{10} (and $PM_{2.5}$) and the other air pollutants (co-pollutants)
3. Concentration levels in the Baguio CBD are among the highest (if not the highest) across highly urbanized areas in the Philippines, including Metro-Manila.

2.1.3 Known health impacts of PM_{10} and $PM_{2.5}$

1. Levels of exposure
   - Short-term (24-hour period; 1-week duration; 1-month duration)
   - Long-term (chronic): 1-year period or more
2. WHO health standards
   - For short-term exposure to PM_{10}: 50 µg/m^3
   - For long-term exposure to PM_{10}: 20 µg/m^3
3. Annual mean levels of PM_{10} in Baguio CBD, 2007–2012:
   - 83 µg/m^3 (more than quadruple the WHO recommended standard for long-term exposure)

2.1.4 Epidemiological literature

1. The wider the differential between the actual levels of exposure (85 µg/m^3) and the recommended standard or baseline (20 µg/m^3), the higher the attributable fraction of the related cardio-respiratory health outcome to the air pollutant.
2. Health risk coefficient. For every *10 µg/m^3 increase* in concentration levels of the pollutant above the baseline, a corresponding *xx% increase* in the incidence of the health outcome is robustly predicted. The Baguio CBD PM_{10} Concentration Differential: *83 – 20* = ***63 µg/m^3***

2.1.5 Policy implications

The larger the policy-induced reductions in PM_{10} (by local and national government policy instruments) in the Baguio CBD, the larger the reduction in the numbers of adverse cardio-respiratory outcomes among the exposed population will be.

1. The larger the <u>cost reductions</u> in terms of <u>direct</u> *private* household expenditures and *government* subsidies (*PHILHEALTH* counterpart) in mitigating the adverse impacts of the diseases
2. The larger the cost reductions in terms of loss of economic opportunities of households (or the individual) due to premature loss of life (mortality) or loss of productive time due to illness (morbidity).

2.1.6 Known health outcomes

1. Premature mortality
   a) Respiratory mortality among infants (< 5 years)
   b) Lung cancer mortality in adults (30 years and above)
   c) Cardiopulmonary mortality in adults (30 years and above)
   d) Cardiopulmonary mortality among the elderly (65 years and above)
2. Morbidity
   a) Hospital admissions
      i) Acute bronchitis in children (< 15 years)
      ii) Chronic bronchitis (all ages)
      iii) Cardiovascular disease (all ages)
      iv) Asthma exacerbation (all ages)
   b) Outpatient cases for treatments
      i) Acute bronchitis in children (< 15 years)
      ii) Chronic bronchitis (all ages)
      iii) Cardiovascular disease (all ages)
      iv) Asthma exacerbation (all ages)
      v) Occurrence of respiratory symptoms (ALRI)

2.2 Questions to Physician per Specialist:

Name ________________________________ (optional)
Clinic locations (name of municipality______________)
Specialization: Pedia ______ Adult ______

1. How common is the incidence of these diseases among your patients?

   a) Infants ________________ c) Adults ________________
   b) Children ______________ d) The Elderly_____________

2. Are there other common cardio-respiratory diseases that are not mentioned above? ________________

3. What are the categories (and indicators) used to describe the levels of gravity of these illnesses? (e.g., mild – serious – severe)

   a) _____________________ c) _____________________ e) _____________________
   b) _____________________ d) _____________________

4. What are the adverse physiological impacts to the patient afflicted with this illness, according to the level of gravity? ____

5. What are the medical treatments (recommendations) to the patient suffering this illness, according to the level of gravity (e.g., confinement, change in lifestyle, medication, etc.) ________________________
   ____

6. If hospitalization is required, how long is the hospital stay (minimum – maximum) for observation and treatment, according to the level of gravity? ____
   ____

7. What are the *frequency* and the *duration* of the respective recommended treatment, according to the level of gravity? ____

8. What are the medicines (drugs) prescribed to treat the patient, according to the level of gravity (Generic; Branded)? ____

9. What is the recommended dosage of the prescribed medicines (drugs) and number of days of treatment, according to the level of gravity? ____
   ____

10. What are the medical equipment prescribed to treat the patient, according to the level of gravity?
    ____

11. What would be the estimated cost of this equipment
    i) If purchased ____
    ii) If rented (e.g., from hospital) _______________________________

12. How can fairly accurate information (data) on the separate (by item) and total cost of treatment of the patient be obtained in a most efficient way from hospital or clinic information? ___________________
    ____

13. Are there any other measures to treat the patient that will impose costs per expenditure on the part of the patient's household that were not mentioned above? _____________________________________

14. Is there a standard percentage of treatment costs that Philhealth shoulders for these diseases? Or is it on a case-to-case (illness-based)? ____
    ____

Thank you very much.

Appendix 3. Caution in the Use of PM_{10} Concentrations as Indicator in Estimating Health Impacts and Cost of Illness of Exposure to Outdoor Air Pollution When Diesel Emissions are the Main Generators of Particulate Matter in a Particular Location

Prior to 2007, DENR EMB-CAR used TSP in measuring air pollution concentrations in the Baguio CBD. In 2007, a PM_{10} monitoring machine was installed at the intersection of Session Road and Magsaysay Avenue of the CBD. Since then, concentrations in PM_{10} were adopted as the indicator for levels of air pollution from particulates. Starting 2013, PM_{10} monitoring stations were also established in three other locations outside the CBD.

PM_{10} refers to particulates of an aerodynamic diameter of less than 10 µm. Thus, the PM_{10} machines are capturing not only coarse particulates, but in terms of health impacts, also the more hazardous fine and ultrafine particulates, although their respective concentration levels are not known.

The finer particulates are defined as follows:

- $PM_{2.5}$ – fine particles of diameters below 2.5 µm
- Ultrafine particles – particles of diameters below 0.1 µm or 100 nanometers (nm)
- Nanoparticles – particles characterized by diameters of less than 50 nm.

The WHO advocates for countries to have local measures of $PM_{2.5}$ so that local authorities can take measures to control the levels of this pollutant when actual levels exceed certain health standards. In the absence of $PM_{2.5}$ machines, particularly in many localities in developing countries, measures of PM_{10} are accepted as the indicator of the behavior of pollutants that have known adverse impacts on human health. Thus across countries, measures of PM_{10} are more widely available than those of $PM_{2.5}$.

$PM_{2.5}$, however, is the more crucial indicator in predicting health impacts; thus, the WHO employs particular conversion factors to obtain "converted $PM_{2.5}$ values derived from actual data obtained from PM_{10} measures. The conversion factors are obtained from observed regular relationships between concentrations in PM_{10} and $PM_{2.5}$, respectively, in particular locations where data in both are available. In European countries, for large urban centers, the conversion factor revolves around a relatively high mean value of 0.67, as the main generators of particulates are motor vehicles. For such a value, if PM_{10} data is registered at 100 $\mu g/m^3$, $PM_{2.5}$ concentration would be around 67 $\mu g/m^3$.

In developing countries where PM_{10} data are available (but not for $PM_{2.5}$), the conversion factors are generally lower. Taking a sample of groups of countries in the WHO Air Quality Report of 2014, the various conversion factors used for designated cities are the following:

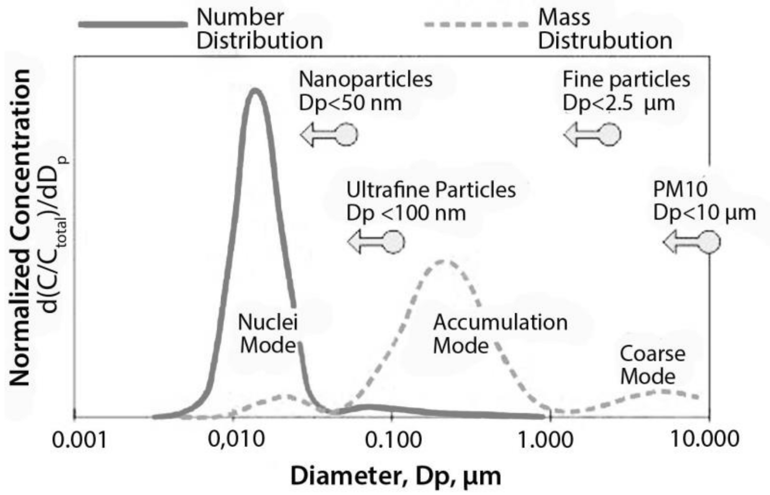
- 0.44: Indonesia, Maldives, Myanmar, Nepal, and Sri Lanka
- 0.46: China, Malaysia, Mongolia, The Philippines, and Viet Nam
- 0.53: Thailand

In the WHO Air Quality Report of 2014, all three cities of Baguio, Metro Manila, and Cebu have converted $PM_{2.5}$ values using a uniform conversion factor of 0.46. With the recent installation of a $PM_{2.5}$ monitoring machine at the Baguio Burnham Lake (Park) area in May 2014, as was presented in the previous section, the 13-month mean ratio of $PM_{2.5}$ to PM_{10} was computed to be 0.67. This relatively high figure approximates the relationship between $PM_{2.5}$ and PM_{10} in the European countries referred to by the WHO 2014 Report. This high ratio is also consistent with the WHO observation when the main generators of particulate matter a motor vehicles.

The recently available data on $PM_{2.5}$ concentrations in the Baguio Burnham Lake monitoring station reveals that previous estimates of $PM_{2.5}$ concentrations for the Baguio CBD area, given the known values of PM_{10} over the years, grossly understates the gravity of exposure of the public to concentrations of the finer particulates that are more hazardous to human health than the coarser particulates that are captured in the PM_{10} readings.

The previous section describes PUJs plying Baguio CBD routes are all run by old, used diesel-powered engines imported from abroad. In addition, a high proportion of the taxi cab units used as public transportation also use diesel fuel.

The above information is significant as studies have shown that for diesel engine emissions, the nanoparticles, ultrafine particles, and fine particles ($PM_{2.5}$) dominate in terms of particle numbers and particle mass as compared to the coarse particles (Hall et al. 2001). Appendix Figure 1 below is lifted from the website article "Diesel Exhaust Particle Size." The article notes that the figure uses a logarithmic scale for particle aerodynamic diameter.



Appendix Figure 1. Diesel particulate size distribution

Source: "Diesel Exhaust Particle Size", https://www.dieselnet.com/tech/dpm_size.PHP

The above information should put caution on relying on PM_{10} information, and changes in its level, in estimating the magnitude of impact on attributable mortality and morbidity at the local level, and the corresponding COI and death. While various epidemiological literature have come up with health risk coefficients relating exposure to PM_{10} concentrations to the incidence of particular types of death and illnesses, the estimates vary depending (to a certain extent) to the relative importance of fine and ultrafine particles embedded in the recorded PM_{10} measures.

The health risk coefficients in epidemiological studies report estimates at the mean. They also report the 95% CIs. This study adopted the mean values of the health risk coefficients as reported by Martuzzi et al. (2002). With the information that the motor vehicles used for public transportation in the Baguio CBD are dominantly run by diesel engines, and knowing that fine and ultrafine particles dominate the distribution of particulates in diesel emissions, it is more likely than not that the true value of the health risk coefficients associated with exposure to PM_{10}, as recorded, would lie at the upper end toward the higher limit of the 95% coefficient intervals. This implies that the public is put at a greater health risk to exposure to diesel emissions in the Baguio CBD than what the study initially predicts.

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