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Particulate matter (pm10) and respiratory health assessment of the selected public elementary schools of cagayan de oro city

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Abstract

This study is aimed to assess the respiratory health condition of students in selected Elementary Schools in Cagayan de Oro City in consideration of their demographic profile and concentration levels of particulate matter of 10 microns size within the area. Random sampling technique and utilized cross-sectional descriptive type of research was used for the respiratory incidence. Determination of PM10 concentration levels was done using 24-hour continuous sampling method with PQ 100 PM 10 Sampler. Two elementary school institutions near traffic area were chosen serving as primary subject in the study. These are the City Central School and East City Central School. Comparatively, the results show that the East City Central School had greater percentage of respiratory incidence than the City Central School in terms of family income, family history, no. of hours of exposure, length of years and crowding. The results also showed that there is stronger influence of PM10 concentration at the East City Central School (49.54µg/m^3) than that of the City Central School (43.59µg/m^3). There exists a directly proportional relationship between the reported incidence and concentration of particulate matter, i.e. that the higher the concentration, the higher the reported respiratory incidence in all of the socio-demographic profile regardless of age and gender. The results shall serve as basis for both schools to come up with achievable strategies to minimize exposure of students against respiratory illnesses such as requiring students to wear personal protective equipment (ppe), growing buffer trees inside the school campus and to undertake activities that generates airborne dust at nighttime only. The local government unit shall also craft policies/ordinances such as re-routing vehicles to ease traffic condition so that emission of harmful air pollutants are easily dispersed to minimize detrimental health effects particularly to elementary students.

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Introduction

Traffic congestion is defined as overflowing of vehicles or a slow movement of vehicles in which the traffic volume surpassed the capability of road area (Zhang, 2010). It is one of the most influential world problems especially in third world countries like the Philippines. According to Dora (2012), traffic depicts a good scenario in terms of employment and business transactions. However, it creates more negative impacts such as health risk, road injuries and noise pollution. In fact, these are common cases in highly urbanized cities such as Metro Manila, Philippines, where high rates of death occur due to poor air quality (Delizo, 2016). Poor air quality can be caused by the release of toxic pollutants that in most cases go beyond the normal standards (EPA, 2014) and this, in turn, produce health effects especially respiratory problems. Young children are mostly affected.

Children in schools can be prone to health hazards most especially if they are exposed to roadways within a few hundred meters – about 500-600 feet downwind from the vicinity of heavily travelled roadways or along corridors with significant trucking traffic or rail activities (EPA, 2014). The city of Cagayan de Oro covers an area of 562 kilometers and has 264,139 registered vehicles (Namoco, 2013). In fact, there is an average of 729 public utility jeepneys passing nineteen (19) streets of the city (Namoco, 2013). This, in effect, can cause traffic in the busy streets of Cagayan de Oro. In a day, Don Apolinar Velez Street has an average of 27,277 volume of vehicles and Claro M. Recto Avenue has an average of 36,143 volume of vehicles (DPWH Region 10, 2013).

These two streets belonged to the top five (5) busiest streets of Cagayan de Oro (DPWH, 2013). A great number of vehicles produce traffic which, in turn, can release air pollutants that can go beyond the normal air quality standards (EPA, 2014). Air pollutants in high concentrations can result to health risks most especially among young children and the elderly.

This study is focused on young school children in relation to their reported respiratory cases and exposure to Particulate Matter of 10 microns size (PM10). It has been studied that young children are susceptible since their immune system and lungs are not fully developed than adults (Scwartz, 2004).

Moreover, other studies have reported associations between residential proximity to busy roads and a variety of adverse respiratory health outcomes in children, including respiratory symptoms, asthma exacerbations, and decrements in lung function (Kim *et al.*, 2004). There are also reports that students attending schools close to major roads can be exposed to traffic-related air pollution even while indoors (Diapouli *et al.*, 2007). This infers that pollutants from outdoors can infiltrate into classrooms. PM10 are harmful emissions due to its ability to penetrate into the inner part of our body especially the lungs (EPA, 2016). Thus, there is a need to assess respiratory cases among young children in school and their exposure to PM10.

This study can help in disseminating information on health and condition among young school children exposed to particulate matters present in the air. This study is aimed to assess the incidence of respiratory cases in schools located near traffic roads of Cagayan de Oro City, specifically, at City Central School, Don Apolinar Velez St., and East City Central School, Claro M. Recto Avenue, Lapasan, Cagayan de Oro City.

Specifically, it sought to answer the following objectives: (a)to measure the concentration of Particulate Matter (PM10) in the vicinity of the schools; (b)to determine whether or not the concentration of PM10 exceeded the National Ambient Air Quality Standards (NAAQS) as provided for under the 1999 Clean Air Act; (c)to record and compare the incidence of respiratory cases among enrolled grade school students; and (d)to describe the relationship between the respiratory cases and exposure to PM10 in terms of age, sex, family income, family history, usual number of hours spent outside the classroom in a day, usual number of hours staying in the classroom in a day, number of years spent in the school and crowding.

Materials and methods

Research Design

This study is a cross-sectional descriptive type of research. It only represents a snapshot overview of respiratory cases taken from two schools exposed in a particular concentration of PM10 from the traffic streets of Cagayan de Oro. Sampling of respondents was done by interviewing parents of grade school students in a random manner.

This ensured that the data gathered during the survey were reliable and credible. Fig. 1 shows the conceptual framework used in the study that served as a guide to describe dependent and independent variables.

As shown in the framework, the independent variable consists of factors of attaining respiratory diseases which are the socio-demographic profile in relation to the location of the two school institutions.

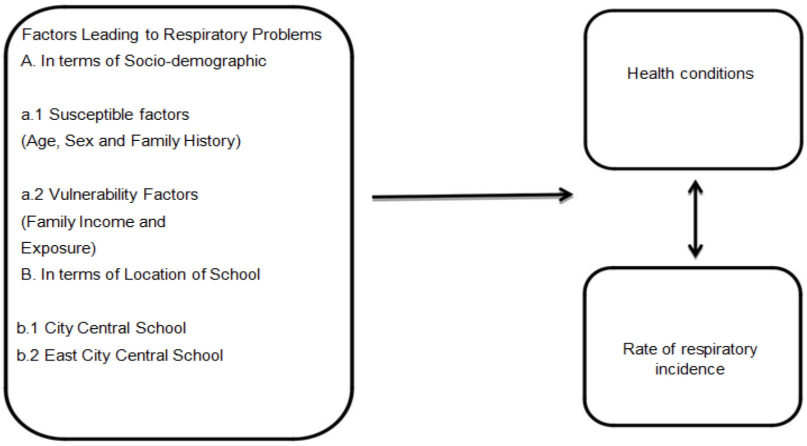

Fig. 1. Conceptual framework used in the study.

Research Setting

The researchers chose to measure the particulate matter (PM) 10 concentration because the association of the concentration of pm 2.5 is not quite applicable due to no conversion kit according to DENR-EMB air quality standards because in Cagayan de Oro City, the common Particulate Matter concentration is PM10. The study conducted at the flagpole area of City Central School, Don Apolinar Velez St. Cagayan De Oro City, and East City Central School, Claro M. Recto Avenue, Lapasan Cagayan De Oro City as it was shown in Fig. 2.a and 2.b. The 300 out of 6268 students of the study were the respondents that were presently enrolled in the City Central School, Don Apolinar Velez St. Cagayan De Oro City with the coordinates: 8.28798 and 124.38717 that had 140 classrooms with an average of 56 students. It covers an area of 37766 square meters.

The 300 out of 3360 students of the study were the respondents that were presently enrolled in the East City Central School, Claro M. Recto Avenue, Lapasan Cagayan De Oro City with the coordinates: 8.28799 and 124.38717 that had 82 classrooms with an average of 50 students. It covers an area of 2958 cubic meters. In the collection of the particulate matter, the equipment was installed in front of the flagpole area. The identified sampling sites for the research study were selected to represent public schools near traffic areas. The flagpole area was selected because students spent more time in the area for practice and other activities.

Description of the Study Area

In City Central School as shown in Fig. 2A, the equipment was installed in front of the flagpole area where all school activities and rehearsals were held. The sampling site has nearby parking lot for vehicles. The 300 out of 6268 students of the study were the respondents that were presently enrolled in the City Central School, Don Apolinar Velez St. Cagayan De Oro City with the coordinates: 8.28798 and 124.38717 that had 140 classrooms with 60 students.

It covers an area of 37766 square meters. In East City Central School (Fig. 2B), the equipment was likewise installed in front of the flagpole area where all activities and rehearsals were undertaken. At the back of the flagpole area, there were ongoing construction activities.

The 300 out of 3360 students of the study were the respondents that were presently enrolled in the East City Central School, Claro M. Recto Avenue, Lapasan Cagayan De Oro City with the coordinates: 8.28799 and 124.38717 that had 94 classrooms with 50 students. It covers an area of 289 square meters.

Fig. 2. A Site of City Central School.

Fig. 2. B Site of East City Central School.

Data Collection

Selection of Respondents for Survey

Before the conduct of the study, researchers sought consent from the school officials. An ocular inspection was also conducted around the schools to choose representative sites where sampling will be undertaken.

A face-to-face interview was done to conduct the survey in collecting data for respiratory cases among grade school children enrolled in the school sampled. In order for data to be credible, parents were the ones asked to be interviewed for ten (10) minutes in behalf of their children who are currently enrolled in the school. A survey questionnaire was interpreted by the researchers in vernacular for them to answer items which include socio-demographic profile and respiratory case/s their children had in the past 6 months. The following is the criteria for enrolled grade school children to be included in the statistical analysis:

1. The respondents were the parents of children ranging from grade one (1) to six (6) with more than six (6) months spent in school except for the kindergarten level.
2. The chosen respondents should know the respiratory health incidence of their children.

PM10 Collection Method

Fig.s 3 and 4 shows the data collection flow and the process of the determination of PM10 on sampled areas. The collection of particulate matter with 10 microns in diameter (PM10) took only once where the air sampler equipment, PQ100, was operated for twenty-four (24) hours. For the safety of the equipment, the air sampler was placed in the covered court. This ensured that the equipment will not be affected by any external conditions such as rain. The Whatmann filter paper intended for PQ 100 was desiccated in the Dry Keeper Sanplatic for 24 hours. Then it was tared and weighed in the Sartorius Microbalance. The filter cassette was opened through the use of a filter cassette separation tool. The filter paper was transferred by using forceps. Then, the filter cassette was placed in a petri dish.

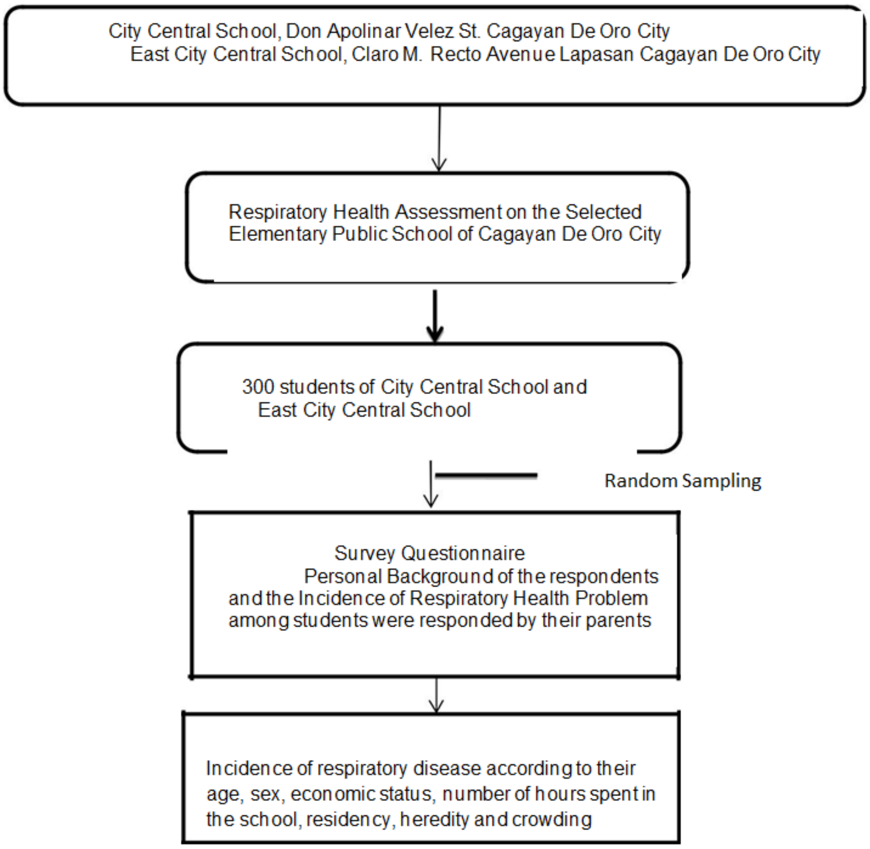

Fig. 3. Flow Chart of the Sampling and the Data Collection in the study.

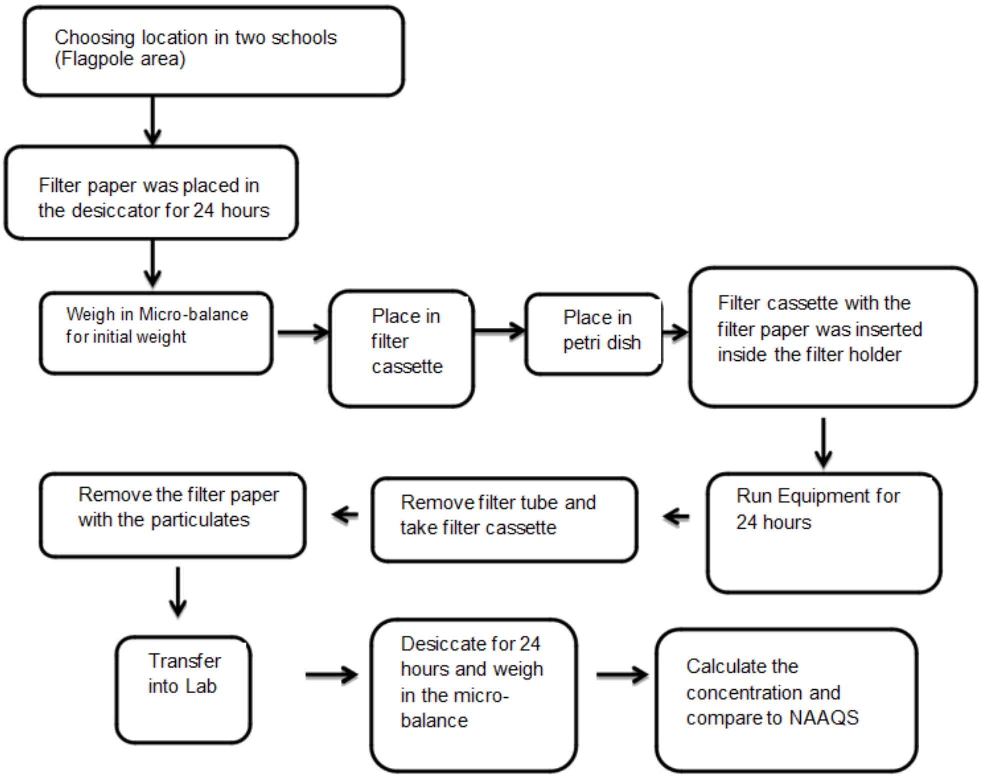

Fig. 4. Flow Chart on the Collection of Particulate Matter in schools located near traffic roads.

The PQ100 was used to measure the PM10 in 5 liters per minute in 0.01 increments with 0.5% calibration. The prepared filter cassette was inserted into the tube of the PQ100 by opening the inner part of the filter screen. After the twenty-four (24) hours of operating the PQ100 for collecting PM10, the data was recorded and the filter cassette was removed in the filter tube. Then, the filter cassette was placed in the petri dish. This was transported to the laboratory for weighing. In the laboratory, the filter cassette was desiccated for 24 hours in the Dry Keeper Sanplatic. Then, this was tared and weighed in the Sartorius Microbalance for the measurement of the final weight.

The difference in the weights before and after PM10 collection represents the mass of PM10 collected using PQ 100 PM10 sampler.

Calculating the Concentration of PM10

The flow rate volume was determined first by multiplying the 24 hours in time and 16.7 as the flow rate. The hours would be converted into minutes. The pressure is expressed in millimeters of mercury and temperature in Kelvin.

The flow rate volume; the standard and actual barometric pressure and standard and actual temperature were multiplied in order to get the standard volume. The filter weight was also calculated by finding the difference between final weight and initial weight, as described earlier. In order to get the concentration, the difference of both two weights was divided into the standard volume.

Formula:

Va = 16.7 $\textit{Liter per minute} \times 1740 \textit{ minutes}$

$$\text{Concentration} = \frac{(Final\ weight - Initial\ weight)}{(Vstd)}$$

Formula for Vstd

$$\text{Vstd} = \frac{\text{Va x (Pa x Tstd)}}{\text{(Pstd x Ta)}}$$

Where:

Pa = actual barometric pressure

Pstd = standard barometric pressure

Ta = actual temperature

Tstd = standard temperature

Va = Flow Rate Volume

Vstd = Standard Volume

The Concentration of each two school institution was compared into the National Ambient Air Quality Standards. Fig. 5 shows the process of analyzing data collected from the survey. The descriptive analysis analyzed and focused on the respiratory incidence that had greater or equal to 50 respondents that were being targeted in which it described as a common incidence. It is a possibility of the effectiveness of the particulate matter concentration. It is for giving evidence whether the common incidence with two respective concentrations had a difference.

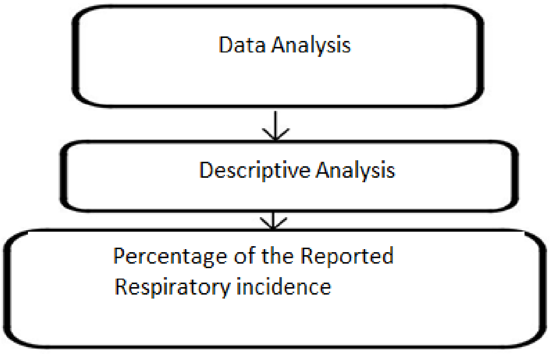

Fig. 5. Data Analytical Procedure

Descriptive Analysis

The respiratory incidence that was based on their demographic profile was presented by the graph in a form of percentage. The incidence was computed through percentage in every set of the demographic profile. The respondent's diseases were being divided into the total population of the respondents in order to get the percentage. The total population compose of untargeted and target respondents. The purpose of getting the percentage of both two school institutions was to see the difference to each other that can be related into the PM10 concentration within the ambient air of the sampling areas.

Results and discussion

This section presented the data obtained from the results of the survey conducted in City Central and East City Central Schools of Cagayan de Oro City. Survey includes socio-demographic and respiratory cases reported by the parents of the grade school children enrolled in the said schools being sampled.

The number of respiratory cases in terms of their age, sex, economic status, family history, number of hours spent outside and inside the classroom, number of years in current school and crowding are also described in this section. This is to relate the incidence of respiratory cases among grade school children to the PM10 concentration collected in the schools sampled.

PM10 Concentration in Sampled Schools

Table 1 shows the results of PM10 collected in different schools located near traffic roads of Cagayan de Oro. The PM10 collected in this study represents the one-day sampling activity. As seen in the results, the East City Central School in Claro M. Recto Ave. has a higher concentration of PM10 than the City Central School. In reference to the standards of the National Ambient Air Quality Standards (NAAQS), the annual mean for PM10 is set to 50µg/m³.

The PM10 of 49.54µg/m³ in East City Central School is very close to the annual mean standard for PM10 set by the NAAQS.

Table 1. Particulate Matter (PM10) Concentration collected from City Central School and East City Central School.

Sampled Areas	PM 10	National Ambient Air Quality Standards
City Central School	43.59µg/m³	Annual Mean of 50µg/m³
East City Central	49.54µg/m³	

Based on the recorded number of vehicles from DPWH (2013), Claro M. Recto Ave. has the highest number of traffic count compared to Don Apolinar Velez St. Approximately, there are 36,143 vehicles passing in Claro M. Recto. Ave. and 27,277 vehicles in Don Apolinar Velez St.

The high concentration of PM10 in East City Central School may have been contributed by air pollutants coming from the busy street of Claro M. Recto Ave (Abu-Allaban *et al.,* 2006). Another factor that can also contribute to the higher concentration of PM10 in East City Central School is the on-going construction activities taking place inside the school premises as it agrees with the study of Gauderman *et al.,* (2017) that construction activities generate high level of dust that is dispersed long distances.

Respiratory Cases in Different Socio-Demographic Profile of the Respondents

This section describes the incidence of respiratory cases among the sampled grade school children in City Central and East City Central Schools. Respiratory cases were described according to the different risk factors that may relate the cases to the concentration of PM10 collected from the different schools.

The identified risk factors include age, sex, family income, family history, number of hours spent outside and inside the classroom, number of years in current school and crowding.

Fig. 6 shows respiratory cases reported among the students in City Central School (A) and East City Central School (B) according to their sex. In City Central School, the number of female (26.3%) and male (26%) students who responded were almost the same while in East City Central School, the number of male (25.66%) is lesser than that of females (23.65%).

The common respiratory cases reported in both schools with more than 50 percent of the students were cough and running nose. Apparently, cough and running nose were common in both male and female. In terms of gender, cases of cough were being dominated on male on City Central School (72%) and female on East City Central School (72.30%).

High Cases of running nose were being shown on female respondents (66.67%) in City Central School and male respondents (70.39%) in East City Central School. In connection with the concentration, the concentration of PM10 in East City Central School (PM10 = 49.54 µg/m³) had a greater concentration than the City Central School (PM10 = 43.59 µg/m³).

indicates that there is no difference in terms of percentage. It is because each school institutions had different leading gender in terms of respiratory diseases. Gender has no significant relationship to PM10 concentration (Dimitrova *et al.,* 2012) on children. Other sources say that gender differs only on the puberty stage of a human organism since development comes in with unique mechanism in fighting air pollutants as it agrees on the study of Venn *et al.,* (2010).

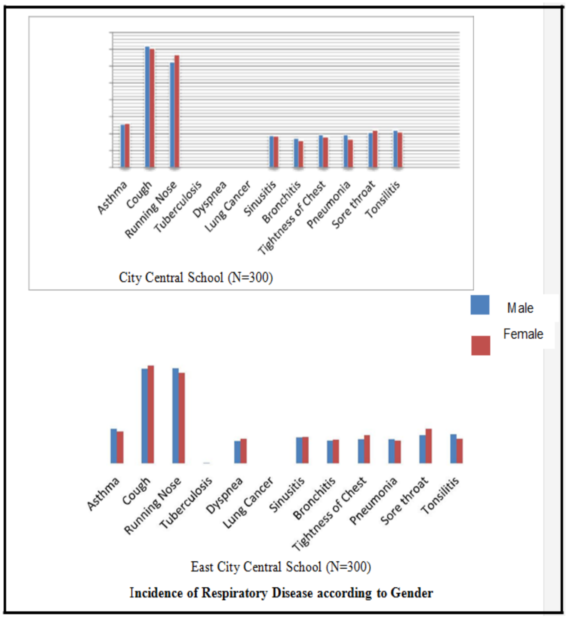

Fig. 6. Percentage of Respiratory Diseases according to gender in (A) City Central School and (B) East City Central School.

The Fig. 7.A and 7.B shows the incidence of respiratory cases in City Central School (A) and in East City Central School (B) according to age of the grade school children. There were more than 50 percent of all age groups who have cough and running nose in both schools.

For other respiratory cases in both schools, less than 50 percent reported on asthma, tuberculosis, dyspnea, lung cancer, sinusitis, bronchitis, tightening of the chest, pneumonia, sore throat and tonsillitis. Cough and running nose are both common respiratory cases caused by different factors that may trigger reactions most especially among young children.

According to the Canadian Pediatric Society Infectious Diseases and Immunization Committee (2005), cough and running nose targets young children due to their weak immune system. Additionally, children are more susceptible to respiratory diseases than adults because due to immunological, physiological and social reasons (Montnemery *et al.,* 2000).

Another reason is that the children breathe more air than adults in which it can verified that they inhale more air pollutants (L. L. Kong *et al.,* 2001).

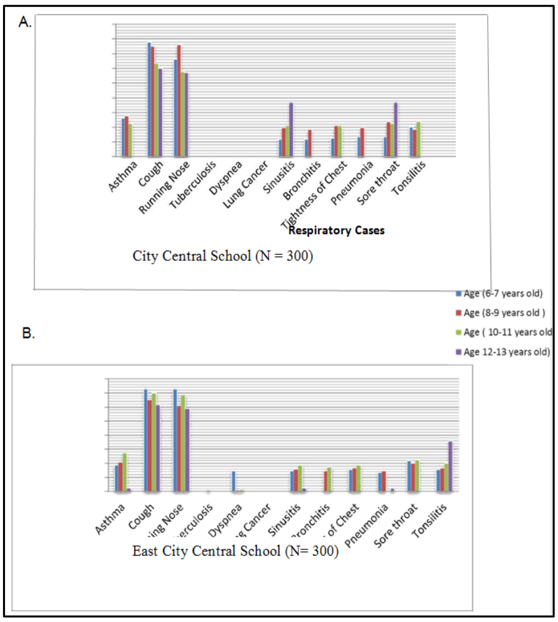

Fig. 7. Percentage of Respiratory Diseases according to age in (A) City Central School and (B) East City Central School.

Central School (A) and East City Central School (B). In terms of family income in both schools, the common respiratory cases reported were cough and running nose with more than 50 percent of them have these. However, it seems that low income earners have higher incidence of cough and running nose compared to high income earners. High percentage of low income group was due to poor housing that leads to experience respiratory diseases because of overcrowding (Ballesteros, 2010). Another is the low-income consider as risk factor to COPD and asthma (Wijnhoven *et al.,* 2001).

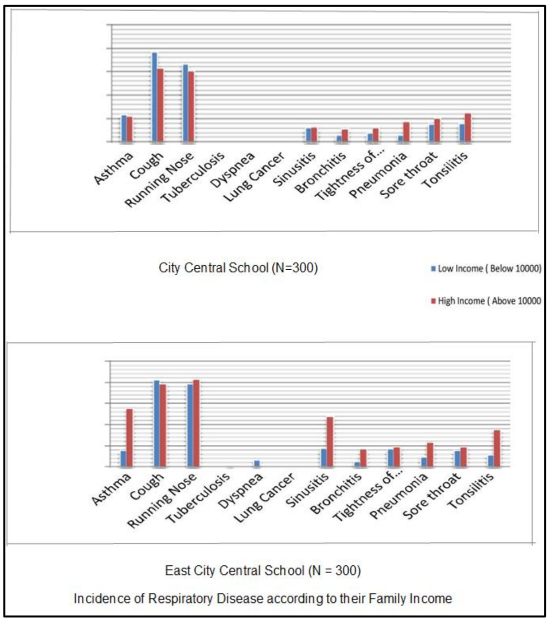

Fig. 8. Percentage of Respiratory Diseases according to Family Income in (A) City Central School and (B) East City Central School.

In terms of the concentration of PM10, City Central School has lower PM10 concentration in the ambient air than East City Central School. Even though the concentration of PM10 in East City Central School (PM10 = 49.54 µg/m³) had a greater concentration than the City Central School (PM10 = 43.59µg/m³), the concentration itself cannot define any difference in the incidence of cough and running nose. It agrees that there is no threshold level of PM10 concentration that respiratory diseases or deaths occur (Hoek *et al.,* 2009) and (WHO, 2000). There is no specific age since there is no specific concentration that can affect the respiratory health of the public. Fig. 8 shows respiratory cases in terms of family income in City

Apparently, other respiratory cases such as asthma, sinusitis, and bronchitis, tightening of the chest, pneumonia, sore throat and tonsillitis were lower among low income earners than higher income earners. These said respiratory problems are usually caused by allergens. It generally reveals that the high concentration of particulate matter can affect the high income even though it has protection against environmental hazard. The high percentage of high income group supported the study of the World Health Organization (2014) that the high incidence of high income happens due to their greater exposure to harmful pollutants. Additionally, lifestyle of high income earners can be close in respiratory diseases because they are more exposed to unhealthy diet and harmful products that can lead their body to be weak in fighting the air pollutants (WHO, 2014).

Fig. 9 shows percentage of respiratory cases of children with family history in City Central School (A) and East City Central School (B). As shown in the graph, the leading cases of with parent history in City Central School were bronchitis (50%) and pneumonia (50%) while in East City Central School was sinusitis (100%). On the other hand, the most highlighted respiratory case in terms of without parent history was pneumonia which is both trendy in two school institutions. In connection with the without parent history group, all of the East City Central School's respondents had pneumonia while in City Central School half of them had pneumonia. From all of the results in heredity, with family history had greater incidence compared to the without family history in East City Central School while in City Central School. The results are varied thus it proves that the genes modify the response of the exposure of the particulate matter concentration in the respiratory system (Scoggins *et al.*, 2004) in which the response is based on the concentration, i.e. the higher the concentration, the higher the response of the genes. As can be gleaned from the above results, the East City Central School with higher concentration than the City Central School coincides with the percentage results of diseases showing higher number in East City Central School (more than 60%) than City Central School (less than or equal to 50%). The results of high percentage of family history supports the study conducted by Hernandez *et al.* 2006 that family history has stronger risk factor of diseases.

Fig. 10.A and 10.B show the students who had particular no. of hours spent in school with respiratory cases. The common respiratory cases found in two school institutions were the cough and running nose. In terms of common respiratory cases, there was a high percentage of cough (84.90%) and running nose (79.25%) to students who spent more than 9 hours in both schools but more pronounced in City Central School with 100% cases.

Overall, longer hours of exposure leads to acquisition of more respiratory diseases (Green, 2016) depending on the concentration of particulate matter.

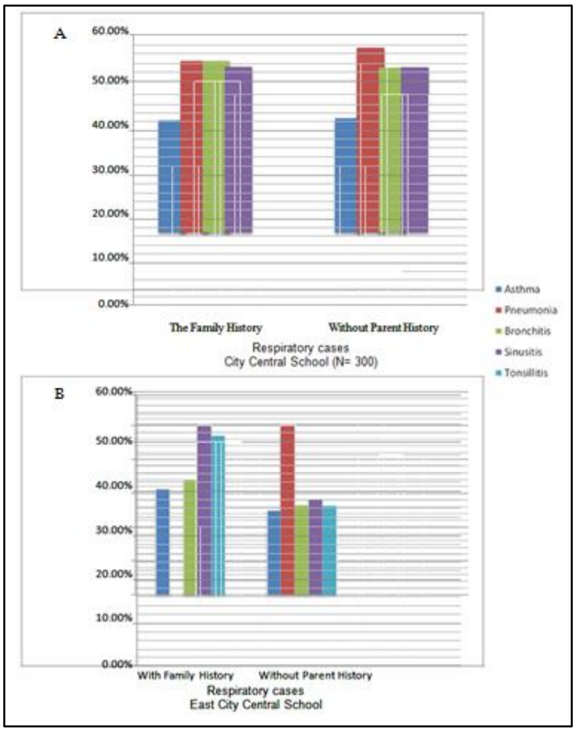

Fig. 9. Percentage of Respiratory Diseases according to Family History in (A) City Central School and (B) East City Central School.

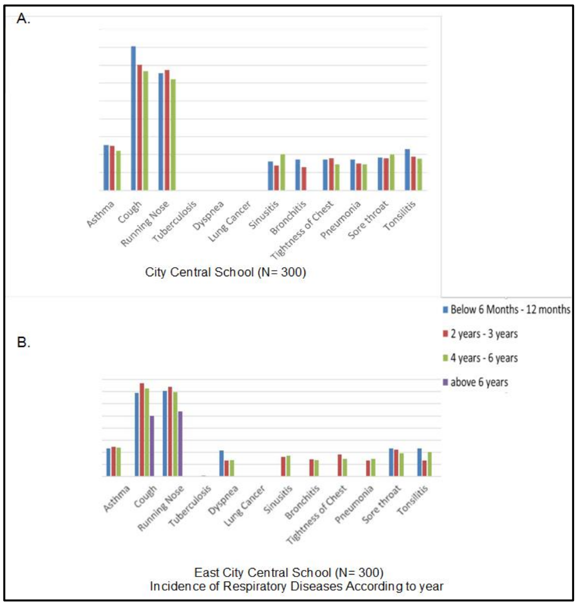

Fig. 10. Percentage of Respiratory Diseases according to Length of Years in (A) City Central School and (B) East City Central School.

At the East City Central School, with particulate matter concentration of 49.54µg/m³, students are exposed to more types of respiratory diseases than at the City Central School (43.59 µg/m³). Hence, students exposed to air pollutants at higher concentration levels in long hours are affected with more diseases.

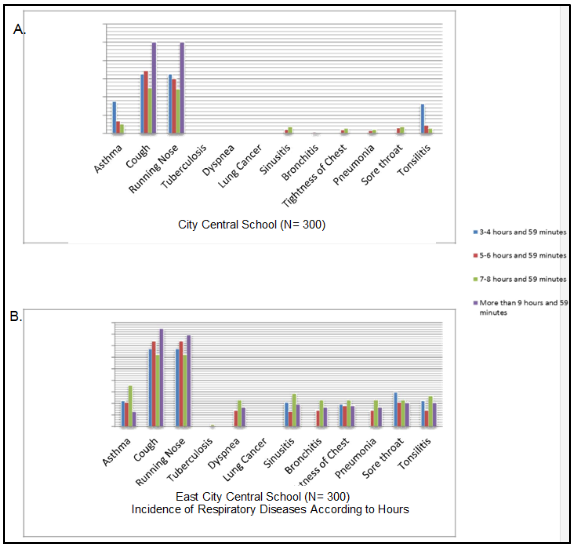

Fig. 11. Percentage of Respiratory Diseases according to time of exposure in (A) City Central School and (B) East City Central School.

These findings support the studies conducted by Dockery *et al.* 2004 that increased concentration leads to decreased lung function. Fig.s 11.A and 11.B show the percentage of students in the City Central School and East City Central School with respiratory diseases based on their schooling experience.

Generally, the two school institutions had 20% reported respiratory incidence except for cough and running nose. The common respiratory cases reported in both schools affecting more than 50 percent of students are cough and running nose. In terms of schooling experience, cases of cough and running nose (80%) on the short year exposure were the same in both school institutions. But only in the East City Central School show the negative effect into long year exposure (50%) in running nose and cough. Consequently, the concentration of PM10 in East City Central School (PM10 = 49.54µg/m³) had a greater concentration than the City Central School (PM10 = 43.59 µg/m³) results an indication of differences on its negative effect on increasing the incidence on cough and running nose to students enrolled. Mostly, the results were being found on the 2-3 years when students continuously accumulate particulate matter rather than those with long year exposure who became tolerant to the degree of particulate matter concentration. Another is that the exposure durations from a few minutes up to a year have been linked with adverse effects (Brunekreef *et al.,* 2009).

But the high percentage of incidence of long year exposure in East City Central School means that high concentration leads to decreased lung function (Brugha *et al.,* 2004).

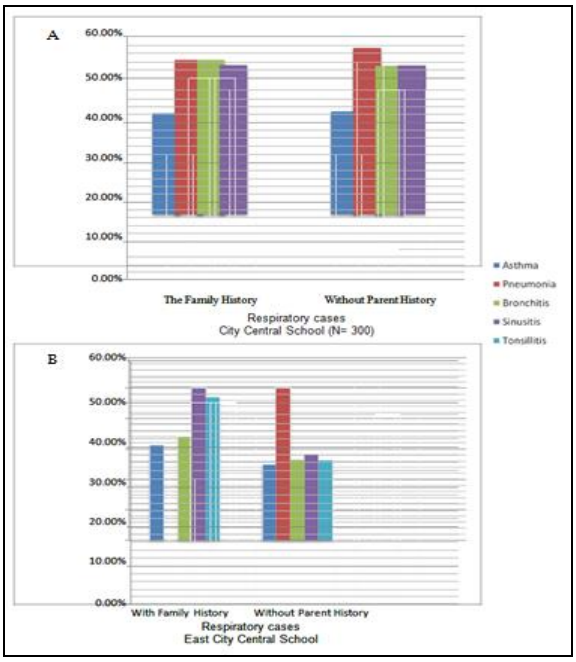

Fig. 12. Percentage of Respiratory Diseases according to Crowding in (A) City Central School and (B) East City Central School.

Fig.s 12.A and 12.B show the incidence of respiratory symptoms on the elementary students of City Central School and East City Central School based on crowding. The common respiratory diseases are cough and running nose in both schools. In terms of percentage, overcrowding in City Central School (80%) was greater than under-crowding (65%). While in East City Central School, percentage of under-crowding and overcrowding is almost the same.

Based on the results, overcrowding has chances of spreading respiratory diseases (Ballesteros, 2010). Additionally, overcrowding has a significant relationship to the diseases (Pearson *et al.,* 2000). In terms of PM10 concentration, the East City Central School (49.54µg/m³) is higher than that of the City Central School (43.59µg/m³) which means evident in higher incidence into overcrowding and under-crowding on high concentration.

Another causes that affects the air quality is due to topography (terrain), such as mountains and valley (R.E.Ducret. Stich *e al.,* 2013), because there is a hill at one side of the East City Central School which prevents air scavenging to take place as shown by the results of cough and running nose for both overcrowding and under-crowding.

Conclusion

The East City Central School had greater particulate matter concentration than the City Central School but both results are still within the standards as provided for under the 1999 Clean Air Act on National Ambient Air Quality Standards. In terms of respiratory diseases, the East City Central School had greater percentage on its respondents than the City Central School. Leading diseases such as cough and running nose were present in all of the risk factors except family history. Sinusitis had only prevailed on the family history. The East City Central School had the rare and common respiratory cases unlike the City Central School had only common cases. In connection with the respiratory diseases, the concentration plays a vital role in proving that the greater the concentration, the greater the reported respiratory incidences in all of the socio-demographic regardless of age and gender.

Recommendation

Based on the results, it is recommended that the academe must implement tree planting activities as buffer against airborne dust from vehicles and to undertake other activities that are sources of dust at nighttime to minimize exposure of students during school days. It is also recommended that a policy addressing this concern shall be crafted as basis for compliance.

The policy shall include requiring students to wear dust masks while inside the school campus. Likewise, the people living nearby the school areas must increase their Knowledge, Practices and Attitudes (KPA) such as wearing protective gears against air pollutants for safety of their health.

The results should also serve as basis in the local urban planning to include re-routing vehicles to other areas of the city to minimize concentration levels of harmful air pollutants. Finally, future researchers may include replicates on each sampling site in order to test significance; range of pollutants that may affect children's health and determination of the type and concentration of pollutants such as heavy metals as basis for policy makers in crafting achievable legislations to address the problem.

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