Relationship Between Road Traffic Exposure and Human Health

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ABSTRACT

Hong Kong is highly urbanised and a substantial proportion of the population lives within proximity to the roadside. The association between long-term exposure to road traffic air pollution and risks to human health has attracted much research attention in western countries but perhaps not enough in Hong Kong, although they have been lobbying topics favoured by environmentalists. This study relates the pulmonary function of samples to the living air quality. The study focuses on five residential areas and five business areas in Hong Kong. Samples are required to take a pulmonary function test. Air pollutants PM<sub>2.5</sub>, PM<sub>10</sub>, CO and CO were monitored as well. Statistical regression was further applied to quantify the significant contributors to pulmonary function. This study showed that the pulmonary function in terms of FVC has a significant difference in different areas. The samples that lived in heavy traffic areas had relatively poor value in terms of FVC. Last but not least, a statistical regression model was conducted and showed that PM<sub>10</sub> and CO have a significant negative impact on lung function. This result raises the alarm about high-density town planning and also expresses the importance of promoting electric vehicles in Hong Kong.

Keywords: Health Impact, Pulmonary Function, Traffic Pollutant, Air Quality.

I. INTRODUCTION

In Europe, various epidemiological studies point to the negative physiological and psychological impacts road traffic has on humans. Air pollutants emitted from road traffic contains chemicals (e.g., nitrogen oxides, particulate matter, carbon monoxide, sulphur oxides) as well as heavy metals and debris which form further downwind of roads and impact adversely on human organs, nervous system, and blood [1]. Long-term and continuous exposure to even low levels of pollutants can be more harmful. The pollution problem is aggravated by climate change.

A respiratory health questionnaire is very common in a children’s health survey. Chen et al. [2] evaluated children’s respiratory symptoms and diseases using a parent-completed questionnaire in six communities in Taiwan. A questionnaire survey was carried out by Tsai et al. [3] among fifth-grade school children in Taipei, Taiwan. The questionnaire was in terms of two parts, one for the school children and the other for their parents. Tabaku et al. [4] conducted a survey to compare the pulmonary function of children living in the urban area of Tirana, Albania with children living in the suburban area of the city.

Qi et al. [5] conducted a study to evaluate the adverse effect of exposure to air pollution on lung function growth in school-aged children in China. In their study, 1983 children were selected from three districts in Guangzhou to perform pulmonary function tests twice, with a time interval of 6 months in between. Children’s respiratory symptoms are reported by parents through completing the self-administered questionnaire in both surveys. The air pollutants level data measured by municipal monitoring stations in Guangzhou was used as reference data and the study concluded that exposure to air pollution had adverse effects on lung function growth of school children.

In Hong Kong, urbanization, economic growth, and lifestyle changes induce road-network sprawl and an increase in the number of vehicle registration at a rate faster than population growth. Mak et al. [6] firstly studied the public transport air pollution impact on children. Through statistical modelling, Mak and Loh [7] further conducted health impact studies for school children. Mak and Loh [8] further conducted Monte Carlo Simulation on vehicle emission and found that roadside pollutant levels could be 20% more for 10% of traffic volume incensement. Both previous types of research suggested that most of the roads in Hong Kong are short, which means vehicles travel at a slower speed with more brakes and starts. Steep urban canyon traps air pollutants and noise and aggravates road-users exposure. Therefore, this study is interested in examining the association of roadside air pollution levels with the health and well-being of residents in Hong Kong with samples from a variety of road designs and building configurations. This research included data gathering through questionnaires and interviews with individuals and actual measurements of pollution levels at the roadside and statistical analyses.
II. METHODOLOGY

It is understood that pollution emission by road traffic depends on a variety of factors including vehicle and exhaust system types, fuel, driving style, vehicle speed, etc. Findings from these studies offered reference points for comparisons with the results of our study as well as measures presently put in place by the Government.

A. Selection of Sites and Sampling

Appendix B of the 2018 Annual Census of Transport Department [9] offered a good starting point for site selection. The 1,660 counting stations listed in Appendix B have selected spots covering the whole of Hong Kong. The mean and median Annual Average Daily Traffic was 24,510 and 15,645 cars per day, respectively. We randomly draw counting stations from this list and select property sites of 500 meters in proximity to the road sections of the counting station. In addition, areas under air flight pathways and 500 meters in proximity to major construction works or major industrial plants were avoided, to ensure that the sampled property sites are typical of Hong Kong's urban living environment and the air pollution measurements we collected in these sites were related mainly to road traffic with minimal contamination from other major sources. Road (including traffic volume estimation, average speed and vehicle types) and weather (e.g., precipitation, wind direction and speed) conditions during the survey period were recorded as well.

Our study requires assistance and cooperation from estate management and household owners for an individual resident survey, installation of video cameras and measurement devices and obtaining topographic diagrams and floor plans of the property. We desire to sample outdoor air and noise level measurements from different locations within the property of various distances horizontally and vertically from nearby roads. Invitations to participate in the survey will be extended to selected households before conducting an initial interview.

B. Construction of the Questionnaire

A set of questionnaires was developed and included self-reporting and periodic interviews with individual respondents. One of the purposes of an initial interview was to obtain consent and enlist the cooperation of the households as well as identify individual respondents for subsequent self-reporting questionnaires and interviews. We were interested in sampling adults between 18 to 65 years of age who have lived in the area for no less than six months. For each site, we targeted no fewer than 20 respondents for each air part of our study and the whole survey period conducted within three consecutive months.

Respondents were aware of the purpose of Health-related. To minimize bias in responses, we made use of “filter questions” to identify the possibility of bias in subsequent survey responses and control for them in subsequent analyses. Miedema & Oudshoorn [10] and Okokon et. al. [11]. For instance, used filter questions to group respondents in their analyses to control for skewness in the distribution of response data.

C. Air Pollution Measurement

Pulmonary function tests on 3957 seventh-grade children and outdoor air pollutants were sampled in Taiwan [12]. They found greater effects of ambient air pollutants on pulmonary function for boys than for girls. Among boys, traffic-related pollutants CO, NO$_x$, NO$_2$, and NO were generally associated with chronic adverse effects on FVC and FEV1. Their data suggest that ambient traffic-related pollution had chronic adverse effects on pulmonary function in school children, especially boys.

The parameters like PM10, PM2.5, CO$_2$, and CO were monitored at the selected sample site for three consecutive days. The equipment while sampling was always at 1.5 m above the ground. Furthermore, it also allowed free of any direct obstructions during sampling.

D. Pulmonary Function Test

Public concern over the health effects of the indoor environment has arisen. Interest has mainly been focused on the potential hazards of tobacco smoke, home dampness, pet-keeping, and Nitrogen Dioxide (NO$_2$). Belanger et al. [13] carried out research on examining associations of indoor NO$_2$ exposure with respiratory symptoms among children with asthma. In this research, NO$_2$ was measured by using Palms tubes. Health-related data were collected during home interviews of mothers of 728 children with active asthma. The samples were younger than 12 years old who lived in sampled homes for at least 2 months and had asthmatic symptoms or used maintenance medication within the previous year. The result showed that exposure to indoor NO$_2$ was associated with increased respiratory symptoms among asthmatic children.

Increased exposure to vehicle exhaust emissions is likely to occur in those children who live near busy roads. Brunekreef et al. [13] found that the association of lung function was strong in children living closest (<300 m) to the motorways. The result was further confirmed by Venn et al. [14] finding that living within 90m of the main road is associated with an increase in the risk of wheezing in children. Therefore, living district and further questions were included in our questionnaire to identify as risk factors.

Exposure to indoor air pollutants is believed to have consequences such as poorer performance for teachers and students because of discomfort or absenteeism [15]. Similar studies had been conducted outdoor; Anderson et al. [16] evaluated an association between community levels of air pollution and asthma prevalence. Statistical analysis was employed on existing data. He however found no evidence of an association between community levels of outdoor air pollution and asthma prevalence.

In this study, we applied spirometry for pulmonary function tests by measuring the amount of air that can be inhaled and exhaled. Model: MIR spirobank G was used in this study. A disposable mouthpiece was needed in the spirometer to conduct a lung function test on each respondent. Before conducting the test, respondents were required to learn how to blow air into the mouthpiece. They are required to perform the test at least three times.

III. RESULT AND DISCUSSION

A. Sampling Location

Ten sampling sites were picked in this study. The selected sites were situated in both urban and rural areas in Hong...
Kong. Five from residential areas (Ma On Shan, Shatin, TKO, Po Lam, Tuen Mun, and five from the commercial area (Mong Kok, Chai Wan, Hung Hom, Causeway Bay, West Kowloon). Questionnaire interviews were carried out by interviewers by cluster sampling. The questionnaire aimed to explore what diseases the respondents were suffering from and also conduct the pulmonary function test for samples. 217 samples performed lung function tests from 10 locations and all of them responded to the questionnaire survey.

B. Participants

217 samples from ages 22-56 in Hong Kong participated in this study. Of those 60 respondents reported suffering from asthma. Furthermore, about 11% suffered from pneumonia; 3% suffered from bronchitis; 6% suffered from sinusitis, and 9% suffered from allergic rhinitis.

C. Forced Vital Capacity (FVC) Sampling Result

This was the total amount of air that can forcibly be blown out after full inspiration, measured in litres. Since COPD causes the air in your lungs to be exhaled at a slower rate and in a smaller amount compared to a normal, healthy person, measuring how well you can forcibly exhale air can indicate the presence of COPD. The mean FVC value of ten sampled sites were shown in Fig. 1. West Kowloon has the lowest mean FVC while Ma On Shan of 4.56 and TKO has the highest mean FVC of 4.59. By statistical ANOVA test, the significance level is 0.000 (p =.000), which is below 0.05 and, therefore, there is a statistically significant difference in the mean between the different sampling sites.

D. Pollutant Sampling Result

According to the WHO IT-1 standard, the acceptable concentration of PM2.5 is 75 µg/m³. Mong Kok, Hung Hom, Causeway Bay and West Kowloon recorded over 75 in average concentration. Both these four sampling sites were located in high traffic areas nearby. Therefore, the sites were expected to exhibit a high concentration of PM. The average concentration of PM2.5 in ten sampled sites were shown in Fig. 2.

According to the WHO IT-3 standard, the acceptable concentration of PM10 is 75 µg/m³. According to Fig. 3, Tuen Mun has the lowest concentration (71.2 µg/m³) among 10 sampling sites. The concentration at West Kowloon and Causeway Bay were found to be over 350 µg/m³.

Carbon dioxide in the majority is an indoor pollutant emitted by humans and correlates with human metabolic activity. Carbon dioxide at levels that are unusually high indoors may cause occupants to grow drowsy, get headaches, or function at lower activity levels. Indoor levels are an indicator of the adequacy of outdoor air ventilation relative to indoor occupant density and metabolic activity. The concentration of carbon dioxide in all sampling sites was found to be within the good class (1000 ppm) as per Hong Kong’s indoor air quality objective.
Carbon monoxide (CO) is one of the most acutely toxic indoor air contaminants which is colourless. It is usually produced as a side product of incomplete combustion of fossil fuels and vehicle emission. The concentration of CO in Mong Kok, Hung Hom, and Causeway Bay were found to be exceeding good class (8.7 ppm) as per Hong Kong indoor air quality standard. This high concentration can be attributed to automobile exhausts.

Fig. 5. Average Concentration of CO in different sampling sites.

E. Pollutant Sampling Result

A statistical regression model was further used to establish the relationship between FVC and average air pollutant concentration. The lung function FVC value was considered the dependent variable and the other four average pollutant concentrations were considered independent variables. The formula is shown below.

\[ \text{FVC} = 6.328 - 0.003 \times (\text{PM}_{10}) - 0.137(\text{CO}) \]

The regression model is important to quantify the effect of each factor on pulmonary function. The formula revealed that of that pollutant, only PM10 and CO were significant (significant value \( = 0.000 \)) in the regression model. The coefficient of both pollutants was negative, it represented long term exposure under PM10 and CO hurt lung function.

IV. CONCLUSION

The association between long-term exposure to road traffic air pollution and risks to human health has attracted much research attention in western countries. However, Hong Kong is an extremely crowded city with tall buildings and a close distance between heavy traffic roads and residential areas. In this study, we directly related pulmonary function to the air quality in ten sampling sites. This study showed that the pulmonary function in terms of FVC has a significant difference in different areas. The samples that lived in heavy traffic areas had relatively poor value in terms of FVC. Last but not least, a statistical regression model was conducted and showed that PM10 and CO have a significant negative impact on lung function. This result raises the alarm about high-density town planning and also expresses the importance of promoting electric vehicles in Hong Kong.

V. LIMITATION

In the study, only 217 samples were selected in this research. The sample size is relatively small. The numbers in the samples of various age ranges were not evenly distributed. This study did not cover any samples that were over 56 years old. Although the results showed significant differences for some sampling sites, no firm conclusions can be drawn for the elderly age range. Lastly, this study was carried out in October 2019. The air quality measured may have had seasonal fluctuations.

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CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

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