Traffic-related air pollution and Hong Kong school children: abridged secondary publication

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KEY MESSAGES

Generally, poorer respiratory health was associated with higher level of air pollution at school environment and higher total traffic count surrounding school.

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Introduction

Traffic exhaust is a principal source of ambient air pollution in urban areas. Gasoline- and diesel-powered vehicles emit various pollutants including carbon monoxide, nitrogen oxide, black carbon (BC), volatile organic compounds, and particulate matter (PM); all of which pose health risks. Traffic has been reported to be associated with respiratory symptoms, poor pulmonary function, wheezing, and asthma.[1,2] However, results have not always been consistent,[3] partly owing to inaccuracies in exposure assessments.

There is limited knowledge about air pollutants that are most likely to affect health.[4] Studies have focused on mixtures of air pollution, but different pollutant sources and components have different effects. A large proportion of pollution is attributable to exhaust fumes from diesel-powered vehicles, which have more serious health consequences than gasoline fumes. Optimal legislation and control strategies require accurate exposure assessment and adverse health effects characterisation of traffic-related air-borne pollutants.

Methods

This was a cross-sectional study. We chose 12 primary schools based on their nearby roads and traffic densities. The schools were grouped into three categories: (1) schools surrounded by main roads with a high traffic density, (2) schools surrounded by roads with mid-level or low traffic density, and (3) schools far away from main roads. We invited all years 2 to 6 students to participate in a health survey. Among approximately 2800 invited students, 2319 (1148 boys and 1171 girls) participated.

Height and weight were measured with light clothing and with no shoes on. The spirometry tests were conducted with Micro Medical SpiroUSB in accordance with the standardised criteria of the American Thoracic Society. The lung function parameters evaluated included the forced vital capacity, forced expiratory volume in the first second, peak expiratory flow, and maximum mid-expiratory flow (MMEF).

Information on non-infectious rhinitis completed by parents or guardians was retrieved. Non-infectious rhinitis was defined as affecting children who have had nasal symptoms (such as nasal blockage, sneezing, and running nose) and itching eye or lachrymation in the absence of common cold in the previous 12 months. Those who answered ‘yes’ were asked to state the months during which they had rhinitis. Only those children whose responses were consistent were deemed to have rhinitis.

Information on self-reported respiratory diseases was also retrieved. Parents were asked whether the children had been diagnosed with the following diseases by a doctor in the past 12 months: asthma, allergic rhinitis, sinusitis, bronchitis, bronchiolitis, pneumonia. Those answering ‘yes’ to any one of the diseases were asked to indicate the months in which their child was diagnosed. Only those children whose responses were consistent were deemed to have respiratory diseases.

Air quality assessments in the school environment and on the main roads surrounding each school were conducted. To address seasonal variations, the assessment was conducted twice (once in summer and once in winter), each for 4 to 5 days during school time (8:00 am to 3:00 pm), generally in front of the main buildings in the schools. One or two routes (main road) surrounding the schools were also assessed using the mobile real-time air monitoring platform. PM 2.5 was measured by TSI DustTrak Aerosol Monitor. Nitrogen dioxide

(NO2), ozone, and carbon monoxide were measured by gaseous analysers; BC was measured by the aethalometer.

Data analyses were carried out using SAS 9.3 (SAS Institute, Cary [NC], USA). All P values were derived from two-sided statistic tests, and those <0.05 were considered statistically significant. Mix linear regression and logistic regression analyses were used to assess the relationships between health outcomes and the school environment air pollution as well as the traffic counts.

Results

The mean age of participants was 9.5±0.81 (range, 7-14) years. 49.5% were boys. The mean body mass index was 17.6±2.8 kg/m^2. Baseline characteristics were similar across the three school categories (Table 1).

Generally, higher levels of air pollution were associated (not necessarily significantly) with lower lung function parameters, except for the pollutant ozone (Table 2). PM 2.5 was significantly associated with a lower forced expiratory volume in the first second and a lower peak expiratory flow, after adjusting for potential confounders. PM 2.5, BC, NO2, and total traffic count were significantly associated with lower MMEF level after adjusting for potential confounders.

PM 2.5, NO2, and total traffic count were significantly associated with the occurrence of rhinitis. PM 2.5 was also significantly associated with self-reported respiratory diseases (Table 3).

Discussion

We investigated the respiratory health effects of air pollutants (PM 2.5, BC, NO2, and ozone) in the school environment and the traffic counts surrounding the schools. Generally, a higher level of air pollution was associated with poorer respiratory health in students, consistent with a previous study.[5] Specifically, a higher level of PM 2.5 was associated with lower forced expiratory volume in the first second, peak expiratory flow, and MMEF, and a higher prevalence of rhinitis and self-reported respiratory diseases; a higher level of BC was associated with a lower MMEF; a higher level of NO2 was associated with a higher prevalence of rhinitis; and a higher traffic count was associated with a lower MMEF and a higher prevalence of rhinitis.

MMEF was the most sensitive parameter. A lower MMEF level was associated with levels of PM 2.5, BC, and NO2 as well as total traffic count after adjusting for potential confounders. MMEF is an important indicator of a small airway function. Our study suggests that air pollution mainly affects the small airway function.

PM 2.5 was associated with health outcomes. This implies that PM 2.5 may contain various toxic chemicals. The total traffic count (but not the diesel vehicle count) was positively associated with a lower MMEF and a higher prevalence of rhinitis. This may be due to the poor correlations between traffic volume surrounding the school and pollutant concentrations in the school environment.

Our findings have important public health implications. Our results suggest urgency to develop strategies on air pollution mitigation in the school environment to protect children's health. Higher traffic volume surrounding schools was associated with poor respiratory health in primary schoolchildren. This finding suggests that urban planning for school location should consider the effects of traffic exhaust on school environment.

TABLE 1. Baseline characteristics of participants*

Characteristic	Overall	Schools surrounded by main roads with a high traffic density	Schools surrounded by roads with mid-level or low traffic density	Schools far away from main roads
Age, y	9.5±0.81	9.6±0.85	9.42±0.89	9.64±0.88
Male	49.5	49.1	50.1	48.9
Height, cm	135.9±7.6	136.6±8.2	134.9±7.9	136.1±8.1
Weight, kg	32.8±8.1	33.4±8.7	31.9±8.5	33.1±8.3
Body mass index, kg/m^2	17.6±2.8	17.7±3.1	17.3±3.0	17.6±3.5
Forced vital capacity, mL	1977±353	2002±355	1938±358	1991±356
Forced expiratory volume in the first second, mL	1734±299	1751±302	1694±306	1757±310
Maximum mid-expiratory flow, mL/s	1984±453	2012±477	1950±463	1991±563
Peak expiratory flow, mL/s	3949±686	4013±733	3859±736	3974±563
Rhinitis	38.4	37.8	40.5	39.1
Self-reported diseases	35.4	38.2	33.6	36.2

* Data are presented as mean ± standard deviation or % of participants

TABLE 2. Association between lung function and air pollutants / traffic counts in the primary school children

Lung function parameter	Unadjusted model		Adjusted model	
	Effect estimate (95% confidence interval)*	P value	Effect estimate (95% confidence interval)*	P value
Forced expiratory volume in the first second				
Particulate matter 2.5	-15.4 (-40.2 to 10.5)	0.31	-32.6 (-56.5 to -2.1)	0.033
Black carbon	-15.3 (-31.6 to 5.7)	0.140	-20.8 (-38.1 to 8.5)	0.12
Nitrogen dioxide	-4.1 (-19.4 to 12.3)	0.58	-7.3 (-18.9 to 11.7)	0.62
Ozone	7.8 (-14.9 to 30.6)	0.48	9.7 (-12.8 to 29.6)	0.49
Total traffic count	-10.3 (-36.1 to 12.8)	0.45	-15.2 (-40.2 to 3.6)	0.48
No. of trucks and buses	-13.7 (-28.6 to 21.4)	0.69	-16.6 (-29.4 to 7.3)	0.55
Forced vital capacity				
Particulate matter 2.5	-12.6 (-36.8 to 20.5)	0.68	-15.1 (-36.5 to 19.5)	0.54
Black carbon	-8.6 (-40.1 to 17.4)	0.42	-10.3 (-38.7 to 21.1)	0.47
Nitrogen dioxide	-4.8 (-28.2 to 19.7)	0.66	-6.1 (-28.1 to 19.9)	0.63
Ozone	4.3 (-29.4 to 36.1)	0.75	5. 8 (-26.5 to 32.3)	0.56
Total traffic count	-9.5 (-38.2 to 16.9)	0.38	-13.2 (-49.2 to 8.6)	0.48
No. of trucks and buses	-10.8 (-59.7 to 18.2)	0.68	-15.3 (-60.2 to 14.3)	0.52
Peak expiratory flow				
Particulate matter 2.5	-60.5 (-113.6 to 8.6)	0.05	-51. 1 (-109.2 to -2.3)	0.05
Black carbon	-63.9 (-118.6 to 13.9)	0.07	-49.2 (-99.8 to 10.6)	0.11
Nitrogen dioxide	-14.5 (-59.3 to 31.9)	0.61	-13.7 (-56.1 to 29.2)	0.56
Ozone	37.5 (-31.3 to 101.6)	0.33	39.7 (-22.8 to 121.8)	0.32
Total traffic count	-46.3 (-84.1 to 23.5)	0.36	-48.2 (-86.2 to 23.5)	0.40
No. of trucks and buses	-49.6 (-91.5 to 32.5)	0.51	-51.1 (-96.0 to 29.3)	0.58
Maximum mid-expiratory flow				
Particulate matter 2.5	-56.4 (-89.1 to -27.6)	0.01	-61.8 (-92.7 to -32.3)	0.01
Black carbon	-49.5 (-97.5 to -11.7)	0.01	-53.7 (-106.1 to -11.5)	0.01
Nitrogen dioxide	-16.0 (-54.3 to 21.5)	0.16	-17.8 (-74.2 to 37.8)	0.25
Ozone	40.2 (-13.6 to 98.6)	0.33	45.6 (-21.3 to 96.8)	0.29
Total traffic count	-22.6 (-58.3 to -9.8)	0.01	-26.3 (-60.1 to -11.8)	0.01
No. of trucks and buses	-25.7 (-59.1 to 6.8)	0.17	-26.4 (-64.2 to 11.9)	0.21

* Effect estimates were calculated as changes in per interquartile increase in air pollutant concentration or the traffic counts

TABLE 3. Association between rhinitis/self-reported disease and air pollutants / traffic counts in primary school children

Air pollutant	Adjusted odds ratio (95% confidence interval)	
	Rhinitis	Self-reported disease
Particulate matter 2.5	1.87 (1.14-2.54)	1.72 (1.11-2.38)
Black carbon	1.36 (0.93-2.13)	1.28 (0.89-2.09)
Nitrogen dioxide	1.21 (1.01-1.98)	1.26 (0.87-2.08)
Ozone	0.98 (0.93-1.81)	0.99 (0.87-1.98)
Total traffic count	1.48 (1.03-2.16)	1.56 (0.98-2.06)
No. of trucks and buses	1.31 (0.84-2.31)	1.24 (0.94-2.26)

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