

Health Effects of Air Pollution on Street Vendors: A Comparative Study in Bangkok

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ABSTRACT

Traffic related air pollutants are a main concern of people living and working along the road. So far a few researches have been conducted to study the adverse health effects of traffic-related air pollutants among street vendors in Thailand. This study aimed to compare the level of traffic-related air pollutants, i.e. fine particulate (PM_{2.5}), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO) and the daily respiratory and other health symptoms reported by street vendors at roadside and residential areas. A 61-day data collection panel study of the daily concentrations of traffic-related air pollutants in the two areas and daily respiratory and other health symptoms was conducted. The concentrations of air pollutants PM_{2.5}, SO₂, NO₂ and CO in the roadside area were much greater than those at the residential area. In addition, 64.0% and 17.0% of 24-hr PM_{2.5} results in the roadside and residential areas respectively were above the standard of 65 mg/m³. An adjusted odds ratio of a series of daily reported health symptoms was estimated with 95% confidence interval between the roadside and residential street vendors. The risk of roadside street vendors developing upper respiratory, lower respiratory and other health symptoms were 2.71-4.42, 3.62-7.82 and 1.54-2.80 times greater than those of residential street vendors, respectively. It is possible to conclude that these excess respiratory and other health symptoms are very likely due to traffic-related air pollutants.

Keywords: Roadside air pollution, health effects, respiratory symptom, street vendors

INTRODUCTION

Air pollution is a major environmental health problem affecting both the developing and the developed countries. Over the past two decades, numerous epidemiological studies have reported an association between air pollution and various health outcomes

such as respiratory symptoms, reduced lung function, chronic bronchitis, daily mortality and hospital admissions.¹⁻⁶

People using road transportation or living near the main roads are more concerned about traffic-related air pollution. Numerous studies have evaluated the health effects of traffic air pollutions including for example, annoyance, total mortality, chronic bronchitis, asthma attacks and allergy, etc.⁷⁻¹⁰

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Bangkok, one of the largest cities in Southeast Asia, has a population of more than 10 million. Vehicle air pollution is a serious environmental problem on the roadsides in the Bangkok area because of a limited number of streets and increasing number of registered vehicles each year. The groups of people who are most at risk of traffic-related air pollutants are street vendors. Working day after day selling their goods on the sidewalks along the streets, there are approximately more than 28,000 street vendors in the Bangkok area. The Pollution Control Department (PCD), Ministry of Natural Resources and Environment, Thailand, consistently reports a high concentration of some air pollutants on the roadside areas of Bangkok.¹¹⁻¹² So far little research has been conducted to study the adverse health effects of traffic-related air pollutants among street vendors. This study intends to compare the level of traffic-related air pollutants, i.e. fine particulate (PM_{2.5}), sulfur dioxide (SO₂), nitrogen dioxide (NO₂) and carbon monoxide (CO), and the 61-day daily reported respiratory and other health symptoms by street vendors in a representative roadside area and a representative residential area.

MATERIALS AND METHODS

This study was a panel study of street vendors located within one kilometer of each of the two air monitoring stations which are approximately 30 kilometers apart. The vendors were roadside and residential street vendors from Dindang district, and Bansomdejchaopraya Rajabhat University - Thonburi district, respectively.

Study area

Two study areas in Bangkok were selected. One area is around the Dindang intersection air monitoring station of the PCD, Ministry of Natural Resources and Environment. The area is one of the

most congested areas with heavy traffic jams in Bangkok. The station is located near Dindang intersection and Victory Monument. The area is a transportation node with several types of transportation, such as buses, cars, vans and electric trains. Dindang intersection and Victory Monument is one of few areas that have the highest number of vehicles in Bangkok area. The number of vehicles in Dindang area is 130,461 per day.¹³ Commuters come to this area for connecting to other buses, vans or electric trains.

The other area was located at Bansomdejchaopraya Rajabhat University, Thonburi district, Bangkok. It was a quiet and peaceful residential area with one university and lot of students walking through. The number of vehicles at Bansomdejchaopraya Rajabhat University, Thonburi district is less than 1,000 vehicles per day (from observation). There were several small communities with narrow streets for people and cars in the area. The air quality monitoring station at Bansomdejchaopraya Rajabhat University was considered the monitoring site of a residential area.

Study population and sample groups

The street vendors were from the roadside and residential representative areas, approximately 159 and 52 street vendors, respectively. Since, the participation in the study was voluntary, eventually; a total of 100 and 41 street vendors in the roadside and residential representative areas voluntarily participated, respectively. A screening interview was conducted using a subject screening questionnaire to identify street vendors with the following criteria: (1) they were selling goods on the sidewalk located within 1 km from either air monitoring station, (2) their age ranged from 15 to 55 years old, (3) they did not smoke or use any protective mask, (4) they did not currently have asthma, allergy, tuberculosis, or chronic bronchitis, and (5) they were willing to participate in the study and give written informed con-

sent. This research project was approved by the Committee on Human Rights related to Human Experimentation, Mahidol University (No 16/2004). Twenty-three and nine street vendors in the roadside and residential areas, respectively, were excluded from being not meet with the inclusion criteria. There were finally 77 and 32 street vendors in the roadside and residential representative areas participated in the study, respectively.

Air pollutants monitoring

The air pollutants monitored at Dindang station were PM_{2.5}, SO₂, NO₂, CO, O₃ and total volatile organic chemicals (TVOCs), together with meteorological conditions and were checked on a daily basis during the 61-day study period (September 1st to October 31st, 2004). At Rajabhat Bansomdej University monitoring station, all the same air pollutants were monitored except O₃ and TVOC, by which the PCD was not monitoring at this site, because the station was located in a residential area.

Symptoms of health and well-being

The participating street vendors were interviewed face-to-face by the researcher and trained staff daily using a questionnaire which was divided into two parts, general characteristics and a daily symptom diary. On the first few days of the interview, the researcher explained about the symptoms to each subject to assure that they understood the differences among symptoms enquired about. The symptoms in the diary were grouped into 3 categories as the following; 1) upper respiratory symptoms e.g. nasal congestion, sore throat or cold¹⁴, 2) lower respiratory symptoms e.g. coughing, phlegm, wheezing, chest tightness or shortness of breath,¹⁴ and 3) other health symptoms e.g. headache, stomach upset, fever, eye irritation, dizziness and weakness. The street vendors were interviewed for any symptoms everyday for 61 days. The percentage of these reported symptoms were then calculated.

Data analysis

The mean, median, range and IQR were used for descriptive statistics. The percentage of daily reported symptoms was calculated on the basis of the followings. If a street vendor reported having one or more of the health symptoms on a given day, one score was given. If they reported having none of some health symptoms, no score was given. If they did not report a yes or no answer to any of the health symptoms, they were taken out of the sample on that day. Then, in each symptom category, the number of subjects reported yes were summed, divided by the total number of reported subjects on that day and multiplied by 100; the result was the percentage of daily reported symptoms of street vendors. An adjusted odds ratio with 95% confidence interval of a series of daily reported symptoms was estimated for 61-day study period between the roadside and residential street vendors using binary logistic regression and controlling for gender, age, fuel used at site (see below) and working duration (months).

RESULTS

General characteristics of street vendors

Table 1 summarizes the general characteristics of street vendors at both sites. A total of 109 street vendors participated in the study, 77 from the roadside and 32 from the residential area. They sold prepared food, snacks, beverages, accessories and cosmetics, flowers, cloth, footwear repairing services, stationary and magazines, etc. The street vendors who sold cooked food and Thai snacks needed to use liquefied petroleum gas and charcoal (for BBQ grills, for example) as fuel for cooking at their stand. The average age of street vendors was 33.4 ± 9 and 31.9 ± 8.1 years for the roadside area and residential area, respectively. Approximately 40% of street vendors in both groups had an education at the primary school level or lower

Table1 Characteristics of street vendors

Characteristics	Roadside area (n = 77)		Residential area (n = 32)	
	Number	%	Number	%
Sex				
Male	12	15.6	9	28.1
Female	65	84.4	23	71.9
Age (years)				
<20	4	5.2	2	6.3
21 – 30	26	33.8	13	40.6
31 – 40	30	39.0	14	43.8
41 – 50	14	18.2	2	6.3
50 – 55	3	3.9	1	3.1
Education				
Primary school and below	31	40.3	12	37.5
Secondary school	16	20.8	8	25.0
High school	19	24.7	4	12.5
Vocational certificate	2	2.6	2	6.3
Diploma	4	5.2	4	12.5
Bachelor's degree	5	6.5	2	6.3
Working years				
< 1	21	27.6	18	56.3
1 – 5	30	39.5	10	31.3
6 – 10	13	17.1	4	12.5
> 10	12	15.8	-	
Duration of working hours				
Min-Max (hr)	2 - 17		6 - 11.5	
Mean \pm SD (hr)	10.1 \pm 2.7		7.6 \pm 1.2	
Sleeping hours				
Min-Max (hr)	2 – 13		5 - 12	
Mean \pm SD (hr)	7.4 \pm 1.4		8.0 \pm 0.8	
Fuel use at sites				
Liquefied petroleum gas	14		5	
Charcoal	7		3	

and 20-25% at the secondary school level. The average working hours of street vendors in the roadside and residential areas were 10.1 ± 2.7 and 7.6 ± 1.2 , respectively. In addition, their average sleeping hours were 7.4 ± 1.4 and 8.0 ± 0.8 for street vendors in the roadside area and residential area, respectively. Only 18.2 and 9.4 % of roadside and residential street vendors, respectively, have ever visited hospitals or clinics for a health examination.

Exposure of air pollutants

The air pollutants in these two areas were compared. Tables 2 and 3 present descriptive statistics for daily air pollutants during the 61-day study period in the roadside and residential areas, respectively. Regarding the monitored 24-hr $PM_{2.5}$, 64.0% and 17.0% of results in the roadside and residential areas, respectively were above the standard of 65 mg/m^3 . In general, the concentrations of air pollutants $PM_{2.5}$, SO_2 , NO_2 and CO in the road-

side area were much greater than those at the residential area.

Daily symptom frequencies

The daily percentages of roadside and residential street vendors who reported symptoms were compiled in Table 4. For roadside street vendors, the most frequent symptom reported was having phlegm (22.36%),

sore throat (8.13%), cough (7.81%), nose congestion (6.88%) and eye irritation (5.07%). The roadside street vendors reported symptoms more frequent than residential street vendors in symptoms such as phlegm, nose congestion, sore throat, upper and lower respiratory symptoms. Street vendors at the residential area had never reported wheezing, chest tightness, shortness of breath and stomach upsets.

Table 2 Daily air pollutant monitoring in the roadside area compared with Thai standard

Air pollutant	Missing* (%)	Mean	Median	Range	IQR [†]	Thai standard
24-hr PM _{2.5} (mg/m ³)	18.03	70.94	72.05	23.20-120.00	52.70-87.10	65
1-hr SO ₂ (ppb)	0	6.34	6.17	3.39-11.30	4.82-7.33	300
1-hr NO ₂ (ppb)	0	52.58	54.46	25.43-78.74	42.91-62.00	170
1-hr CO (ppm)	0	1.43	1.39	0.60-2.51	1.17-1.72	30
1-hr VOCs (ppm)	0	3.57	3.54	2.84-4.73	3.23-3.88	-
1-hr Ozone (ppb)	0	4.65	4.35	1.17-10.22	3.39-5.89	100

* missing = According to the Pollution Control Department, Ministry of Natural Resources and Environment, the missing of PM_{2.5} was commonly occurred due to weather condition, quality control and other technical problems.

† IQR, interquartile range

Table 3 Daily air pollutant monitoring in the residential area compared with Thai standard

Air pollutant	Missing (%)	Mean	Median	Range	IQR	Thai standard
24-hr PM _{2.5} (mg/m ³)	32.79	41.63	42.87	16.29-93.52	23.85-52.25	65
1-hr SO ₂ (ppb)	32.79	3.94	3.39	1.52-10.57	2.32-4.72	300
1-hr NO ₂ (ppb)	8.20	27.84	30.00	8.87-46.78	20.86-34.12	170
1-hr CO (ppm)	4.92	0.53	0.49	0.04-1.41	0.30-0.69	30

Table 4 Percentage of daily symptom frequencies reported by the roadside and residential street vendors

Health Symptoms	Roadside street vendors				Residential street vendors			
	Mean	Median	Range	IQR	Mean	Median	Range	IQR
Upper respiratory symptoms	14.11	14.29	4.35-23.29	11.59-16.91	4.40	3.23	0-9.38	3.23-6.25
Nose congestion	6.88	5.56	0-15.07	4.32-8.76	2.44	3.13	0-6.25	0-3.23
Sore throat	8.13	7.25	4.11-16.44	5.80-10.69	2.13	0	0-9.38	0-3.23
Cold	4.53	4.17	0-13.70	2.74-5.80	4.03	3.23	0-6.25	3.23-6.25
Lower respiratory symptoms	24.84	23.29	15.94-34.72	21.74-27.86	4.51	3.23	0-6.45	3.23-6.25
Cough	7.81	6.85	2.90-20.55	5.80-9.59	1.77	0	0-6.45	0-3.23
Phlegm	22.36	21.92	14.49-29.17	18.84-26.39	4.51	3.23	0-6.45	3.23-6.25
Wheeze	0.24	0	0-1.47	0-0	0	0	-	-
Chest tightness	0.59	0	0-4.35	0-1.41	0	0	-	-
Shortness of breath	0.72	0	0-2.90	0-1.45	0	0	-	-
Other health symptoms								
Headache	4.49	4.17	0-11.59	2.76-6.85	1.75	0	0-6.25	0-3.23
Fever	2.58	2.78	0-7.25	1.39-4.32	1.55	0	0-3.23	0-3.13
Eye irritation	5.07	4.29	1.37-11.59	2.84-7.10	1.44	0	0-3.13	0-3.13
Dizziness	2.90	2.90	0-8.82	1.37-4.35	1.75	3.13	0-3.23	0-3.13
Weakness	3.46	2.90	0-8.70	2.74-4.35	1.43	0	0-3.13	0-3.13

Table 5 The adjusted odds ratio with 95% CI of a series of daily reported symptoms was estimated between the roadside and residential area. The results are adjusted for gender, age, fuel used at site and working duration (months).

Symptom of deteriorated health/well being	Odds	95%CI
Upper respiratory symptom	3.45	2.71-4.40
Nose congestion	2.71	1.97-3.74
Sore throat	4.42	3.15-6.18
Cold	1.20	0.90-1.58
Lower respiratory symptom	7.82	6.21-9.85
Cough	3.62	2.53-5.20
Phlegm	7.07	5.61-8.91
Other health symptoms		
Headache	2.57	1.75-3.77
Fever	1.54	1.02-2.33
Eye irritation	2.80	1.85-4.24
Dizziness	1.45	0.97-2.17
Weakness	2.31	1.52-3.51

duration (months) (Table 5). The risk of roadside street vendors developing upper respiratory symptoms was 3.45 times that of residential street vendors; the adjusted odds ratio (95%CI) was 2.71 (1.97-3.74) for nose congestion, and 4.42 (3.15-6.18) for sore throats. For lower respiratory symptoms, the risk of roadside street vendors was 7.82 times that of residential street vendors; the adjusted odds ratio (95%CI) was 3.62 (2.53-5.20) for coughing and 7.07 (5.61-8.91) for phlegm. Regarding other health symptoms, the risk of roadside street vendors developing headaches and fever was 2.57 and 1.54 times that of residential street vendors. The adjusted odds ratio (95%CI) was 2.80 (1.85-4.24) for eye irritation and 2.31 (1.52-3.51) for weakness.

DISCUSSION

This study was a panel study enrolled a cohort of roadside and residential street vendors by following them to investigate changes in re-

The absentee rate (for unknown reasons) of roadside and residential street vendors reporting symptoms each day varied from 5.2% to 11.7% with a mean of 8.74% and from 0 to 3.1% with a mean of 1.58%, respectively.

Comparison of health effects

An adjusted odds ratio with a 95% confidence interval of a series of daily reported symptoms was estimated between the roadside and residential street vendors. The results were adjusted for gender, age, fuel used at site and working

duration (months) (Table 5). The risk of roadside street vendors developing upper respiratory symptoms was 3.45 times that of residential street vendors; the adjusted odds ratio (95%CI) was 2.71 (1.97-3.74) for nose congestion, and 4.42 (3.15-6.18) for sore throats. For lower respiratory symptoms, the risk of roadside street vendors was 7.82 times that of residential street vendors; the adjusted odds ratio (95%CI) was 3.62 (2.53-5.20) for coughing and 7.07 (5.61-8.91) for phlegm. Regarding other health symptoms, the risk of roadside street vendors developing headaches and fever was 2.57 and 1.54 times that of residential street vendors. The adjusted odds ratio (95%CI) was 2.80 (1.85-4.24) for eye irritation and 2.31 (1.52-3.51) for weakness.

Characteristics of street vendors

In the process of subject inclusion, street vendors who had anytime before the study developed asthma, tuberculosis and chronic bronchitis were screened out because they were considered a sensitive group and might be vulnerable to develop any symptoms easily. Smokers were also excluded from the study because those who smoke cigarettes might already have problems of respiratory system. Female were predominated in both groups (72-84%). The roadside street vendors had longer experience

as street vendors and longer working hours per day than the residential street vendors. Most vendors had primary and secondary or high school level, therefore using diaries of respiratory symptoms as a tool for vendors to report their adverse health effects was simple and appropriate. When they reported any health effects, they used their own feelings to decide whether they had developed any symptoms or not. The daily diaries of respiratory and other health symptoms have proved to be a valuable tool in this regard because subjects serve as their own control.¹⁶

Exposure of air pollutants

The PM_{2.5} was selected because the motor vehicle emissions constituted the main source of fine and ultra fine particles. The CO and VOCs resulted from incomplete burnt fuel from vehicles exhaust. Sulfur is oxidized mostly to SO₂ on combustion. At high combustion temperature, atmospheric nitrogen is oxidized to nitric oxide (NO) and small quantities of NO₂.¹⁷ This study used ambient air pollution measurements from central monitoring sites, and consequently, misclassification of exposure was a well-recognized limitation of this study.¹⁷ The range of PM_{2.5} concentrations at both areas was very wide; both areas had concentrations of PM_{2.5} which exceeded the USEPA standard of 65 mg/m³. The concentration of PM_{2.5} at the roadside area was higher than that of the residential area due to a higher number of vehicles in the roadside area. Concentrations of sulfur dioxide were quite low in roadside area (3.39-11.30 ppb) and even lower in residential area. Moreover, the other sources of sulfur dioxide in the area were not found. However, the concentrations of NO₂ and CO at the roadside area were almost twice of those at the residential area. The concentrations of NO₂ in this study were greater than a study of two Indonesian studies.^{5, 6}

Daily symptom frequencies

A comparison of daily symptoms reported among street vendors showed that headaches, cold, fever, dizziness and weakness were not significantly different, possibly because vendors worked outdoors, and exposed to sunlight for long working hours. It was noted that four symptoms, namely; wheezing, chest tightness, shortness of breath and stomach upsets, were not reported by residential street vendors. This suggests the residential vendors can breathe adequately and that the quality of air in the residential area may be better. Some street vendors in roadside area reported stomach upset perhaps due to busy selling and did not have time to rest or eat. Some symptoms reported by the roadside street vendors were considerably higher than residential street vendors. These included phlegm and upper and lower respiratory symptoms and probably due to more stressful work conditions combined with higher traffic-related air pollutants in the roadside area.

Comparison of health effects

The roadside street vendors had a risk of developing upper and lower respiratory and other adverse health symptoms which was significantly higher than the residential street vendors, except for the symptoms of cold and dizziness, which were not significantly different between these two groups. The risk of developing four symptoms; namely wheezing, chest tightness, shortness of breath and stomach upsets was not estimated due to the absence of a comparison base, since residential street vendors did not have these symptoms during the study period. The results clearly illustrated that the roadside street vendors had developed upper and lower respiratory and other adverse health symptoms more frequent than the residential street vendors although both groups worked on the pavement along the street. The symptoms reported by

street vendors were likely caused by PM₁₀, PM_{2.5}, O₃, CO, NO₂, SO₂, total VOCs and other environmental factors, such as temperature, humidity, etc. Individual pollutants as well as multiple pollutants emitted from the vehicles on the roads and other confounding factors could be the causes of the symptoms. The relationship between multiple traffic-related air pollutants and adverse health effects are analyzed and discussed elsewhere.¹⁸ If the roadside street vendors are consistently exposed to high concentrations of traffic-related air pollutants, work longer than 8 hours per day, and do not have enough rest each day, they may develop other chronic symptoms or diseases in the future. Moreover, people surrounded by heavily trafficked roads have a higher prevalence of respiratory diseases, and possibility a higher risk of cancer, psychic discomfort and sleep disturbances.¹⁹ Zulkarnain Duki. *et al.*⁵ revealed that the prevalence rate of the symptoms of cough, phlegm, persistent cough, wheezing without cold, and asthma in the studied student and mother groups, were significantly correlated with the NO₂ emitted along large roads. Measures should be taken to reduce exposure to traffic-related air pollutants among street vendors at roadsides with heavy traffic. Street vendors themselves should be informed of and realize the effects of the toxic air pollutants that they breathe everyday, and encourage them to reduce the exposure, by any means possible, including wearing properly effective masks.

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ผลกระทบต่อสุขภาพของมลพิษอากาศกับคนขายของริมถนน การศึกษาเปรียบเทียบในกรุงเทพมหานคร

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บทคัดย่อ

มลพิษอากาศที่เกี่ยวกับการจราจรเป็นความกังวลหลักของประชาชนที่อาศัย และทำงานริมถนน มีงานวิจัย 2-3 เรื่องที่ได้ทำการศึกษาผลกระทบต่อสุขภาพของมลพิษอากาศที่เกี่ยวกับการจราจรของคนขายของริมถนนในประเทศไทย การศึกษานี้มีวัตถุประสงค์เพื่อเปรียบเทียบระดับของมลพิษอากาศที่เกี่ยวกับการจราจร ได้แก่ อนุภาคนาโนเล็ก ($PM_{2.5}$) ซัลเฟอร์ไดออกไซด์ ไนโตรเจนไดออกไซด์ คาร์บอนมอนอกไซด์ กับอาการทางระบบทางเดินหายใจ และสุขภาพอื่นๆ ในแต่ละวัน ที่รายงานโดยกลุ่มตัวอย่างคนขายของริมถนนและบริเวณที่พักอาศัย โดยการเก็บข้อมูลความเข้มข้นของมลพิษอากาศในแต่ละวันเป็นเวลา 61 วัน ในพื้นที่ศึกษาทั้ง 2 แห่ง ผลการศึกษาพบระดับมลพิษอากาศทั้ง 4 ในบริเวณริมถนน มีค่าสูงกว่าในบริเวณที่พักอาศัย นอกจากนี้ร้อยละ 64.0 ของตัวอย่างอากาศบริเวณริมถนน และร้อยละ 17.0 ของบริเวณที่พักอาศัยมีค่า $PM_{2.5}$ 24 ชั่วโมงสูงกว่าเกณฑ์มาตรฐาน (65 mg/m^3) การประมาณ Adjusted odds ratio ของชุดอาการทางสุขภาพที่รายงานในแต่ละวัน ที่ความเชื่อมั่น 95 เปอร์เซ็นต์ ระหว่างคนขายของริมถนนและบริเวณที่พักอาศัย พบว่าความเสี่ยงของคนขายของริมถนนต่ออาการของระบบทางเดินหายใจส่วนบน, ระบบทางเดินหายใจส่วนล่าง และอาการทางสุขภาพอื่นๆ คิดเป็น 2.71-4.42, 3.62-7.82 และ 1.54-2.80 เท่าของคนขายของบริเวณที่พักอาศัย ตามลำดับ เป็นไปได้ที่จะสรุปว่าอาการทางระบบทางเดินหายใจและสุขภาพอื่นๆ ที่มีมากขึ้น อาจเกิดจากมลพิษอากาศที่เกี่ยวข้องกับการจราจร

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