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Urban Environmental Health: Respiratory Illness and Urban Factors in Kuala Lumpur City, Malaysia

Oliver Ling Hoon Leh [a,b], Shaharuddin Ahmad [a], Kadaruddin Aiyub [a], Yaakob Mohd Jani [a] and Ting Kien Hwa[b]

[a] *Faculty of Social Sciences and Humanities, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi Selangor, Malaysia*
[b] *Faculty of Architecture, Planning & Surveying (FSPU), Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Malaysia*

Abstract

With increasing urbanisation, more people are now staying in urban built environments, even though the conditions of the urban environments may not be conducive to urban residents' health. However, with the lack of health data of urban residents, very few studies have been conducted to examine the relationship between urban factors and city residents' health especially in developing countries. Therefore, the objectives of this paper are to examine the rate of respiratory illness (acute respiratory infection and asthma) among residents of Kuala Lumpur City and also to investigate the relationship between the respiratory health rate and urban factors. A questionnaire was distributed to 563 households in the study area. Human health (as measured by acute respiratory infection and asthma) was found to be related to the land acreage of urban land use components, trip generated rate and other urban factors. An increase in shopping and office floor space, and trip frequencies, or decrease of green spaces were found to be related positively with the increasing rate of respiratory illness cases among people living in the Kuala Lumpur City.

Keywords: acute respiratory infection (ARI); air quality; health; respiratory illness; urban

1. Introduction

The earth is pressured by rapid urban population growth and physical development. In 2008, for the first time in history, the proportion of the population living in urban areas reached 50 percent (United Nations, 2007). A global population increase of around 2 billion people is expected for the 2000 to 2030 period and will mainly be concentrated in the urban areas of the less developed regions (Camhis, 2006). Due to the high concentration of population in urban areas, cities are under development pressure. Urban areas attract more people through plenty of job opportunities, comprehensive urban services and modern urban lifestyle. Consequently, these factors have increased pressure on cities to increase their densities as well as the size of urban areas which, in turn reduces the green spaces in the cities. The natural ecosystems are increasingly replaced by urban built-up areas due to rapid urban growth (Li *et al*., 2005).

Beside the degradation of natural environment and reduction of natural land covers, vegetation and urban environmental services, the un-sustainable urban development pattern (mono-use zoning and low density, sprawl and car oriented) also increases the dependence on automobiles as the major transportation means and increases travelling time. High vehicular usage increases the generation of harmful air pollutants and human exposure to air pollutants. One of the leading examples of urban sprawl in the United States of America (U.S.) is the Atlanta metropolitan area where every person travels on average 34.1 miles each day in a car. More densely populated metropolitan areas have far lower per capita daily driving figures than Atlanta, for instance 16.9 miles for Philadelphia, 19.9 miles for Chicago and 21.2 miles for San Francisco (Frumkin, 2002).

In Malaysia, mobile sources (automobiles) are the major sources of air pollutants (Department of Statistics Malaysia, 2006). Statistics around the world such as Klang Valley, Malaysia, Europe, and New York city, U.S. show that air pollution (e.g. Particulate Matter-10 and Nitrogen Oxides) concentrations were higher in the urban environment than in the rural, and highest in high-traffic areas as compared to other urban land uses (Kinney and O'Neill, 2006; Mohamed Elnour *et al*., 2005; Sivertsen, 2006).

Respiratory and cardiovascular diseases are susceptible to air pollutants throughout the world (Botkin & Keller, 2003; Kinney & O'Neill, 2006). Studies have been carried out to examine the relationship between air pollutants and respiratory/cardiovascular diseases in laboratories using animals as subjects, in controlled chambers, or in human clinical studies (Forastiere *et al*., 2006; Lippmann and Ito, 2006). Relationship studies have also been carried out in several U.S. cities (NIEHS, 2007), Manila and Chinese cities (WHO-Western Pacific, 2005) including Beijing (United Nations, 2001). These investigations showed a significant relationship between various types of air pollutants and respiratory diseases. For instance, a study in the South Coast Air Basin (SoCAB) of Southern California demonstrated that eye and throat irritation were the most frequent effects of ozone (O_3) exposure (Hall, 1996).

In Malaysia, a very limited number of studies have been carried out to examine the relationship between urban factors, air quality and the health of urban inhabitants. Rafia *et al*. (2003) and Norela *et al*. (2008) examined the possible health effects (acute respiratory infection (ARI), asthma and conjunctivitis) of forest fires (haze) by using public hospital data but not the health data of the residents. A study on identification of risk factors in childhood asthma at Ipoh General Hospital via self-administered questionnaires was carried out by Shamarina (1998). The study found that common risk factors among the patients included family history of asthma (65.7%), allergy to dust (53.1%), location of house (37.5% near factory; 34.4% near main road), and presence of smoker or ex-smoker in the house (65.7%).

A study of spatial distribution of bronchitis (one type of lower respiratory infection) with reference to air pollution concentration was carried out in Kuala Lumpur (Shaharuddin, 1990/91). The air pollution concentrations at all planning units were estimated using the total number of traffic volumes at 34 traffic count stations. The study revealed that the relationship between the air pollution (based on traffic volume) potential areas and the bronchitis rates suggested a high incidence of the disease in the severely polluted areas and low incidence in the least polluted areas. The relationship was tested by using correlation coefficient and showed that *r* value of 0.47 which indicated a positive relationship between traffic volume and bronchitis (respiratory infection) rate in Kuala Lumpur.

This paper aims to examine the rate of ARI and asthma among residents in Kuala Lumpur city, and the relationship between the rate of respiratory illness (ARI and asthma) and urban land uses, trip generated and attracted rates, air quality, and exposure period to air pollutant among residents.

2. Study area and Methods

The study was conducted in Kuala Lumpur City (KL), Malaysia. The total land area of the city is 243.7 km^2 (AJM, 2006), which is 100% of urban area. It had a population of 1,556,200 people in year 2005 (Department of Statistics Malaysia, 2005) with an average population density of 6,386 persons per km^2. The study covered all the 6 strategic zones in the Kuala Lumpur City namely Bukit Jalil-Seputeh, Bandar Tun Razak-Sungai Besi, Wangsa Maju-Maluri, Sentul-Menjalara, Damansara-Penchala and City Centre.

A questionnaire survey was carried out to identify respondents' health condition and their socio-economic background with the focus on air related ill-symptoms and the outpatient cases for the period of April 2008 to July 2009. However, this paper discusses only the findings related to respondents with ARI and asthma. By using stratified random sampling technique, 563 households (units of house) were chosen from the total of 440,806 units of house in KL, which covered all the six strategic zones with different types and cost of houses. The survey covers general households (Malaysian only) with various socio-economic, demographic and pre-existing health backgrounds. Table 1 shows the general demographic characteristics of sampled respondents. The sampled respondents include male and female young children (12 years old and below), teenagers and adult (13 to 64 years old) as well as elderly (65 years old and above). The majority of the respondents were Malay and Chinese which were the biggest ethnic groups in KL. Data on of city land uses, trip generated rate, trip attracted rate and population were gathered from public authorities such as City Hall of Kuala Lumpur and Department of Statistics Malaysia. Air quality data were taken for two days (one in weekday and one in weekend) per month for all the six zones in KL for the period of December 2008-March 2009 and May-July 2009. Air quality healthiness level was identified based on the Malaysian Air Pollution Index (API) classification.

Cases of ARI incidence were measured based on reported ARI symptoms by respondents, including cough, nasal discharge, nasal block, sore throat, loss of voice and throat irritation, with a duration of less than 14 days per case (less than 14 days is considered as acute infection). ARI outpatient cases and asthmatic outpatient cases are the cases of getting medical advice or treatment without been hospitalized due to ARI and asthma. Rate of ARI incidence, ARI outpatient and asthmatic outpatient are calculated based on the formula as:

i. ARI incidence rate = (ARI incidence cases ÷ total respondents in each area) x 100
ii. ARI outpatient rate = (ARI outpatient cases ÷ total respondents in each area) x 100
iii. Asthmatic outpatient rate = (asthmatic outpatient cases ÷ total respondents in each area) x 100

Table 1. Demographic background of respondents, by percentage, Kuala Lumpur

Age Group	Percentage of respondents in six zones, KL (%)					
	Bukit Jalil-Seputeh	Bdr. Tun Razak-Sg. Besi	Wangsa Maju-Maluri	Sentul-Menjalara	Damansara-Penchala	City Centre
Age below 13	22.82	26.56	14.66	12.60	14.73	25.83
Age 13 to 64	75.05	72.79	82.33	87.11	83.72	74.17
Age 65 and above	2.13	0.66	3.00	0.28	1.55	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
Ethnic Group						
Malay	25.65	69.51	68.00	22.19	30.23	56.67
Malaysian Chinese	66.38	27.21	16.00	55.34	51.16	38.67
Malaysian Indian	6.90	3.28	16.00	22.47	18.60	2.00
Others bumiputera	1.08	0.00	0.00	0.00	0.00	2.67
Total	100.00	100.00	100.00	100.00	100.00	100.00
Sex						
Male	51.42	46.33	45.08	48.03	50.39	57.34
Female	48.58	53.67	54.92	51.97	49.61	42.66
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total number of respondents	470	305	300	357	129	151
Unit of sampled house (total of 563)	121	97	125	121	47	52

Note: total numbers of respondents are the numbers of interviewed household members from the 563 units of house.

3. Results and Discussion

3.1. Rate of respiratory illness

Table 2 shows the rates of ARI incidence, ARI outpatient and asthmatic outpatient in the study area. The result indicated that the highest ARI incidence rate was reported in the period of October 2008 to March 2009 (wet season) except for Bukit Jalil-Seputeh and Bandar Tun Razak-Sungai Besi. This period of the year, however, was recorded with a better ambient air quality as compared with middle of the year (dry season) (Tables 3). It is contrary with the common assumption that respiratory illness cases should be higher in the middle of the year (dry season) where ambient air quality is generally more polluted than at the end/beginning of the year (wet season). Therefore, respiratory health is not only influenced by ambient air quality but also by the exposure level of individuals to air pollutants and factor of weather or climate change. Besides, there are other factors that potentially affect respiratory health, for example, the impact of allergens and moulds, age and socio-economic factors (Gouveia and Maisonet, 2006; Janssen and Mehta, 2006; Utell *et al*., 2006). Change of temperature and excessive rainfall affect the impact of allergens and moulds on human health (Ayres *et al*., 2009).

There was a different scenario in the City Centre. Table 3 shows the percentage of the days at the various levels of air pollution index (API) for each strategic zone. It is clearly shown that higher pollution levels were recorded in the year end/beginning of the year than during the middle of the year in City Centre. It is similar to the result of higher ARI incidence rates in the year end/beginning of the year (wet season) as compared to the middle of the year (dry season) (Table 2). Air pollution concentration in Wangsa Maju-Maluri was recorded at the same level of both periods of the time, *i.e*., October 2008-March 2009 and May-July 2009. The ARI incidence rates were also very close for both of the periods (Table 2).

Based on the ARI outpatient rates, three areas *i.e*., Wangsa Maju-Maluri, Sentul-Menjalara and Damansara-Penchala showed higher ARI outpatient rates in the period of October 2008 to March 2009 (year end/begin) than in the middle of the year. However, City Centre, Bandar Tun Razak-Sungai Besi and Bukit Jalil-Seputeh showed slightly higher ARI outpatient rates during the period of April to July 2009 (dry season) as compared to October 2008 to March 2009 (wet season).

Table 2. Rate of ARI incidence, ARI outpatient and asthmatic outpatient to total respondents (cases per 100 people), October 2008 - July 2009, Kuala Lumpur

	Period of time		
City Centre	Oct. 08 to Mar. 09	Apr. to July 09	Total
ARI incidence	82	68	150
ARI outpatient	29	30	59
Asthmatic outpatient	4.0	1.3	5.3
Bukit Jalil-Seputeh			
ARI incidence	49	53	102
ARI outpatient	29	30	59
Asthmatic outpatient	0.9	0.6	1.5
Wangsa Maju-Maluri			
ARI incidence	39	38	77
ARI outpatient	30	25	55
Asthmatic outpatient	2.3	2.0	4.3
Sentul-Menjalara			
ARI incidence	33	22	55
ARI outpatient	24	14	38
Asthmatic outpatient	0.6	0.6	1.2
Bdr. Tun Razak - Sg. Besi			
ARI incidence	24	32	56
ARI outpatient	13	19	32
Asthmatic outpatient	0.3	1.0	1.3
Damansara-Penchala			
ARI incidence	16	14	30
ARI outpatient	13	7	20
Asthmatic outpatient	0.0	1.6	1.6

Table 3. Percentage of days for each level of air pollution index (API) for the period of December 2008-March 2009 & May-July 2009

	Dec. 08 - Mar. 09				May - July 09			
	Good	Moderate	Unhealthy	Very Unhealthy	Good	Moderate	Unhealthy	Very Unhealthy
Bukit Jalil-Seputeh	16.67	83.33	0.00	0.00	0.00	83.33	16.67	0.00
Bdr. Tun Razak-Sungai Besi	16.67	83.33	0.00	0.00	0.00	66.67	33.33	0.00
Wangsa Maju-Maluri	16.67	83.33	0.00	0.00	16.67	83.33	0.00	0.00
Sentul-Menjalara	16.67	83.33	0.00	0.00	0.00	100.00	0.00	0.00
Damansara-Penchala	16.67	83.33	0.00	0.00	0.00	100.00	0.00	0.00
City Centre	0.00	83.33	16.67	0.00	0.00	100.00	0.00	0.00
Average	**13.89**	**83.33**	**2.78**	**0.00**	**2.78**	**88.89**	**8.33**	**0.00**

Source: air sampling of Particulate Matter-10, Carbon Monoxide, Sulphur Dioxide, Nitrogen Dioxide and Ozone.

Asthmatic outpatient rates were high in October 08-March 2009 period (wet season) for Wangsa Maju-Maluri, City Centre and Bukit Jalil-Seputeh. However, Sentul-Menjalara, Damansara-Penchala and Bandar Tun Razak-Sungai Besi showed high rates in the middle of the year (April to July) (Table 2). It implies that respiratory illness (ARI or asthmatic) rates are not always high during the dry season (more polluted).

3.2. Relationship between time spent in air polluted areas and respiratory health

Urban residents are not only affected by the distribution of air pollution within their residential areas but also from their working environment. People are exposed to different levels of air pollution concentration due to different environment of working place, transportation, entertainment and exercise. The relationship between time spent by respondent in air polluted area (respondent's exposure to air pollutant) and ARI incidence rate (indicator of health) was tested by using the Spearman rank correlation method. We found that the relationship was significant in most of the zones, except for Damansara-Penchala zone and Bandar Tun Razak-Sungai Besi zone which were not significant even at the 0.10 level. Even though the statistical relationship shows a weak correlation, it implies that people's health is potentially influenced by the exposure level to air pollution.

In most of the areas, the significant relationships were found in the middle of the year only (dry season) (Table 4). It implies that in wet season, air quality in air polluted area has improved, possibly due to the precipitation which decreased the air pollutants. Respondents then inhale less air pollutants even though they are living in the polluted area.

Possibly due to multiple factors of environmental health such as physical and non-physical factors (socio-economic, demography and others), the relationships between respondent's exposure to air pollutant and ARI in some areas were not significant. This is quite acceptable due to the fact that in some areas, reported health conditions might be more influenced by the physical air pollution, but in other areas, people might be more influenced by other factors such as weather and socio-economic conditions.

3.3. Relationship between urban factors and respiratory health level

Table 5 shows the density of population, housing, commercial, trip generated and trip attracted among the six strategic zones. Table 2 shows that the rates of respiratory illnesses varied among the six studied zones. High rates have been measured at the more urbanised areas (more centred area, higher density and more commercial floor space) which were City Centre, Bukit Jalil-Seputeh and Wangsa Maju-Maluri. Table 5 shows

Table 4. Relationship between time spent in air polluted area and ARI incidence of respondents

		ARI incidence (Apr. to Sept. 2008) *Middle of year*	ARI incidence (Oct. 2008 to Mar. 2009) *Year end/begin*	ARI incidence (Apr. to July 2009) *Middle of year*
Sentul-Menjalara				
Time spent in air polluted area (hour/week)	Correlation coefficient (r) Significance level	0.122* 0.010	0.022 0.228**	0.137* 0.000
Wangsa Maju-Maluri				
Time spent in air polluted area (hour/week)	Correlation coefficient (r) Significance level	0.150* 0.340	0.011 0.117*	0.057 0.049
Bukit Jalil-Seputeh				
Time spent in air polluted area (hour/week)	Correlation coefficient (r) Significance level	0.103* 0.153	0.025 0.056	0.066 0.231
City centre				
Time spent in air polluted area (hour/week)	Correlation coefficient (r) Significance level	0.039 0.114	0.637 0.151▪	0.130 0.066

Note: ▪ significant at the 0.10 level
* significant at the 0.05 level.
** significant at the 0.01 level.

Table 5. Density of population, housing, commercial, trip generated and trip attracted among the six strategic zones

Zones	Population (people/km^2), 2005	No. of houses/ km^2, 2005	Shopping floor space, 2010 ('000 m^2/km^2)	Office fl. space, 2010 ('000 m^2/km^2)	Trip Generated ('000 person/ day/km^2), 2005	Trip Attracted ('000 person/ day/km^2), 2005
Bk. Jalil-Seputeh	7,363	2,145	25.85	43.56	14.50	13.81
Bdr. Tun Razak - Sg. Besi	6,483	2,003	10.5	24.12	10.15	9.23
Wangsa Maju-Maluri-Maluri	8,163	2,333	18.42	38.58	11.68	10.60
Sentul-Menjalara	7,473	1,990	21.11	28.73	11.78	10.87
Damansara-Penchala	3,521	832	5.85	22.37	9.48	9.17
City Centre	8,038	1,444	111.21	316.11	62.90	65.48

Source: adapted from Arkitek Jururancang Malaysia, 2006

that these more urbanised areas high in the density of population, commercial floor space (shopping, office), trip generated and trip attracted as compared to other zones in KL. Besides, green area (including forest) per trip generated rate was observed to have low rate in more urbanised zones (high in ARI incidence) which are in City Centre and Bukit Jalil-Seputeh (Table 6). Areas located in urban fringes have displayed low density and were less urbanised and therefore reported with low rates of ARI as well as low rates of asthmatic outpatients (Table 2).

For instance, City Centre, Bukit Jalil-Seputeh and Wangsa Maju-Maluri displayed high rates of ARI incidence and asthmatic outpatients as compared with other zones in KL (Table 2). Sentul-Menjalara has the lowest asthmatic outpatient rates in KL: 1.2 cases per 100 respondents. Thus, the rates were higher in more urbanized/centre areas than in the less urbanised areas.

The relationship between population, land uses, trip generated, trip attracted and green area, and health indicators suggested a high rate of respiratory illness (ARI and asthma) in the more urbanised areas with less green areas and a low rate in the least urbanised areas with more green areas. It implies that increases in population density, commercial, trip generated and trip attracted may increase the rate of respiratory illness (ARI and asthma). In addition, more parks/greens/forest coverage might decrease the rate of respiratory illness.

Urban development especially with the increase of density and commercial development generates and attracts more trips to the urbanised area. Motorised vehicles have been a major source of air pollution, therefore, more trips generated or attracted to the city is potentially increasing the health problems among urban residents if large portion of human trip is catered by motor vehicle. As stated by City Hall of Kuala Lumpur (2008), in 2005 more than 60% of human trips in KL were catered by cars, taxis and motorcycles. In contrast, buses and rails only cater for less than 30% of trips. As stated in the study in Nigeria, industrial communities such as Eleme, which were exposed to high levels of air pollution were more predisposed to respiratory morbidities, skin disorders and other related health risks. The air pollution was significantly associated with respiratory health problem ($p = 0.044$) (Ana *et al*., 2009).

Table 6. Green area per trip generated rate among the six strategic zones

Zones	**Greens (acre/ rip generated rate)**
Bk. Jalil-Seputeh	0.27
Bdr. T. Razak - Sg. Besi	0.37
Wangsa Maju-Maluri	0.50
Sentul-Menjalara	0.62
Damansara-Penchala	0.66
City Centre	0.13

Note: trip generated rate = trip generated ('000 person trip / day) per km^2 of area
Source: adapted from City Hall of Kuala Lumpur 2008; Arkitek Jururancang Malaysia 2006

Green areas and forest are capable of cleaning the ambient air. The more green areas the better the process of cleaning the air and vice-versa. Bolund and Hunhammar (1999) reported that in a park air pollution can be filtered out up to 85% while in a street with trees, air pollution can be filtered out only up to 70%. Vegetation has also been identified as an effective factor of cooling the air locally and reducing downwind. Indirectly, it reduces the photochemical reaction rate in producing secondary pollutant (O_3). This might be the reason for positive relationship between high green coverage area and low health indicators (ARI and asthma). A study in the eastern seaboard from Washington, DC, to central Massachusetts, which has many major urban areas, showed that an increase of urban tree cover from 20% (base urban conditions) to 40% led to an average decrease in urban hourly O_3 concentrations by 1 ppb (2.4%) during daylight hours with a peak decrease of 2.4 ppb (4.1%) (Nowak *et al.*, 2000). However, it led to an increase in O_3 concentrations during most of the nights; an increase in average hourly Nitrogen Oxides (NOx) concentrations during most of the days; and a slight overall increase in O3 concentrations in surrounding areas (Nowak *et al.*, 2000).

4. Conclusions

Human health (as measured by ARI and asthmatic case) was not positively related to the ambient air quality in the respondents' living environment. A lower rate of ARI cases was reported in the dry season as compared to the wet season. However, the health indicators, as measured by rate of ARI and asthmatic cases of the total respondents, showed a high rate (less healthiness) in more urbanised areas (areas closer to city centre, higher density, higher trip and less green area) and a low rate at less urbanised areas. The positive relationship between commercial, trip generated and parks/greens/forest coverage, and the health indicators showed that the increased urbanisation of a city is able to affect human health as measured by ARI incidences, ARI outpatients and asthmatic outpatients.

Human health is not only affected by air pollution in the residential environment, but also in other areas such as workplace, shopping environment, transportation and entertainment/sports area. An increase of exposure to air pollution is potentially affecting the health (respiratory). Therefore, every city development should be well planned and managed for the benefit of all human beings. City developments that rely on high density setting, large areas of commercials and offices, and high dependence on automobile are potentially affecting human health. Medium-high density urban setting with mixed use development, preservation of natural forest and green area is expected to have good impact to human health. Urban planning policies which encourage more mixed use development, preservation of natural forest and green areas would contribute towards the general health of urban population.

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Correspondence to
Oliver Ling Hoon Leh (*Ling OHL*)
Faculty of Architecture, Planning & Surveying (FSPU),
Universiti Teknologi MARA (UiTM),
40450 Shah Alam,
Malaysia.
Email: oli761@yahoo.com
Tel: +6012 2380503