ASSOCIATION OF ASTHMA WITH CARBON MONOXIDE CONCENTRATIONS ON THE ROADS OF KARACHI AND POTENTIAL BLOOD LEVEL OF CARBOXY HAEMOGLOBIN

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Abstract

This paper aims to investigate carbon monoxide (CO) concentrations on roadways of Karachi, potential blood levels carboxy hemoglobin (COHb) in Karachiites and evaluate its association with asthma prevalence in Landhi and Korangi towns of Karachi city. Geographical information system (GIS) was used for spatial analysis of diseases potentiality while an interpolation technique has been applied for surface generation with town boundaries and later evaluates risk areas. The results depicted that the Union Councils wise estimated carboxy hemoglobin (COHb) levels with mean and maximum values were found in the range of 1.24% to 1.86% and 1.35% to 3.06% respectively. This study shows that the asthma prevalence and carbon monoxide values are strongly correlated, indicating higher the CO levels with higher the Asthma prevalence. The higher concentration of carbon monoxide in the ambient is mainly due to automobile exhaust and industrial emissions, resulting in an increase in asthma, other respiratory and heart related diseases.

Introduction

Asthma is a serious concern in masses irrespective of age, color, geographic location, and socioeconomic status. All over the globe people are suffered by this chronic disease. It is estimated by WHO that approximately 300 million people were diagnosed with asthma and 255,000 people died of asthma only in 2005 (WHO 2006). Asthma patients have been doubled over the globe in last two decades (WHO, 2007). Although, it extensively prevails as public health issue not only in low-income countries, it occurs in all nations irrespective of poverty level. Nevertheless, over 80% of asthma deaths are recorded in low and lower-middle income countries (WHO, 2006).

Due to contaminated urban life style respiratory diseases are on the rise especially in developing countries. It has a great impact on human health. Urbanization in the modern sense of the term is the picture of blocks of flats, traffic jams, air pollution, noise nuisance, and growth of slums with several social issues (Sorhaug *et al*, 2006). As a result some dangerous chemicals were deliberately introduced in the environment. These substances in such quantities and of such duration are liable to cause harm to humans and ecology (Marth *et al.*, 1996). These chemical also bring changes in the climate or interfere with the comforts of life and affect human activities. Recent evidence indicates that motorized vehicles are a major source of air pollution, contributing 60% of air pollution containing CO and also for NOx, VOCs, SOx and particulate in urban areas (WHO, 2006, 2007; Afroz *et al.*, 2003; Bono *et al.*, 2007).

Karachi is one of the leading polluted cities in the world. As a massive urban and industrial area there are four human induced dominating air pollution sources, vehicular traffic, Industrial manufacturing units, open air garbage burning and rubber tire burning during public demonstrations. These sources release thousands of tons of toxic gases and particulate matters into the atmosphere of Karachi (Qureshi, 1997).These environmental deprivation processes continue in the city. The air pollution is the major concern which is dangerously affecting the urban areas of the metropolis.

GIS with allied technologies now are recognized as a fundamental toolkit within the area of public health and environmental studies. These technologies are used for representation and analysis of disease incidence data in form of maps (Lawson, 2001; Jerrett *et al*., 2003).In several health studies GIS and related spatial statistics have been used by many researchers (Jerrett *et al.*, 1997; Gatrell and Loytonen, 1998; Moore and Carpenter, 1999; Jerrett *et al*., 2003 and Holton, 2004).The mapping of disease forecasting in public health supports in pre-decisive potential problem areas that report to surveillance and sharing plans (Maantay, 2007). Most recent actions focus on creating maps that show high environmental risks (Holton, 2004). Therefore an attempt was made to locate asthma rise areas and CO, and its impact on COHb level in Landhi and Korangi towns of Karachi city by using GIS.

Materials and Methods

a) Base Mapping: We used QuickBird 2007 satellite image to develop the digital map for the study area on 1: 5000 scale in GIS format by using ArcGIS 9.3. Base map data was modeled in GIS layers viz. Roads, Points of Interests (POIs) and Land use / Land cover (LULC). Published administrative boundary maps by City District Government Karachi (CDGK) were used to define Towns and UCs.

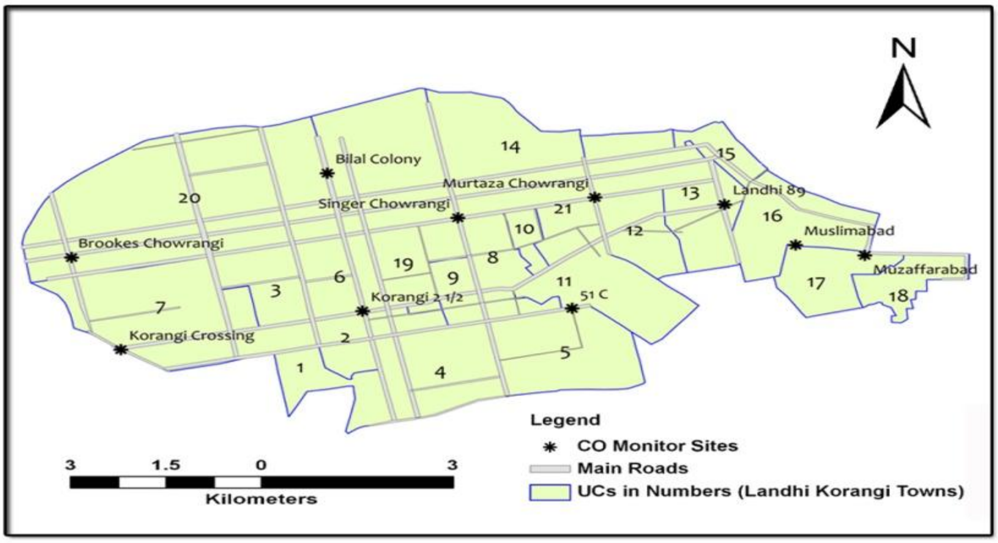
b) CO concentration monitoring: Carbon monoxide is a by-product of fossil fuel combustion. In central part of cities where traffic jams occurs, high concentration of this pollutant create health problem. Discharged CO from motorized vehicles and other sources to air have an indirect effect on climate change, in addition to adverse health effects on exposed humans (Modic, 2003; Afroz *et al.*, 2003). Earlier indigenous studies of CO and its relation with traffic are defined in some classical examples that suggest CO sampling criterion viz. at road intersections where CO potential exist (Arsalan, 2002; Ukpebor *et al.*, 2010).Therefore, CO concentrations were monitored at 10 major road intersections of Landhi and Korangi towns (Fig. 1).At each location the level of carbon monoxide was measured using Snift CO Analyzer (Model 50), continuously from 8:00 to 18:00 (8 hours reading). To find out the variation of CO in each station at different times of the day, hourly concentration of CO was averaged for the same time duration. These calculated values were compared with WHO guidelines.

c) Interpolation through GIS: Interpolation workflow was adopted as described by Arsalan (2002) and performed in ArcGIS 9.3. Inverse Distance Weighted (IDW) method was used that referred to as deterministic interpolation method. This method allocates values to locations based on the surrounding measured values and on specified mathematical formulas that determine the smoothness of the consequential surface.

d) Appraisal of asthma prevalence: Asthma prevalence was appraised through a questionnaire based survey. The questionnaire used in this study was a modified version of International Union against Tuberculosis and Lung Disease (IUATLD's), validated by Burney *et al.*, (1989). Stratified random sampling method was used with 0.1% (N = 987) sample size. All of the 987 respondents were asked to complete an observational, cross-sectional questionnaire regarding asthma symptoms, medication, as well as behaviors toward asthma.

e) Risk evaluation: Carbon monoxide is not highly soluble in water, so it penetrates in lungs and transfers into the blood stream, combines with hemoglobin to form Carboxy hemoglobin (COHb), which impairs the oxygen carrying capacity of the blood. Carbon monoxide enters in the blood stream and reduces the delivery of oxygen to the body's organs and tissues (Gorman *et al.,* 2003). The threat to human health is most serious especially for those who suffer from cardiovascular diseases (Zevin *et al.,* 2001; Daya *et al.,* 2009). In addition Exposure to elevated carbon monoxide level is associated with impairment of visual perception, difficulties in respiration, work capacity, agility, learning ability and performance of difficult tasks. UC wise zonal summaries of CO concentration (viz. minimum, maximum, mean, range and standards deviation) were calculated. The potential COHb level in blood stream was estimated through an empirical equation discussed by Wayne and Ming–Ho (2004).

COHb Blood Level % = 0.16 × Concentration + 0.5: Mean and maximum vales of CO were used for evaluating blood COHb levels. Estimated COHb values were linked with GIS data of Union Councils that finally used for map representation and potential risk areas identification. We made several analytical assumptions for the risk evaluation. We assumed that: people become tainted within the UC of their residence, appraised CO concentration is related to the increasing COHb, and probability of increase in asthma prevalence is higher in UCs with neighboring CO concentration levels. Base data preparation, analytical approach and expected outcomes are detailed in Fig. 2.



ID and UC NAME					
1	Chakra Goth	8	Sherabad	15	Moinabad
2	Mustafa Taj Colony	9	Korangi	16	Daud Chowrangi
3	Gulzar Colony	10	Burmese Colony	17	Muslim Abad
4	100 Quarters	11	Landhi	18	Muzaffarabad
5	Hasrat Mohani Colony	12	Khawaja Ajmeer Colony	19	Zaman Town
6	Sector 33	13	Bhutto Nagar	20	Bilal Colony
7	Nasir Colony	14	Sharafi Goth	21	Awami Colony

Fig. 1. Base map of study area and union councils.

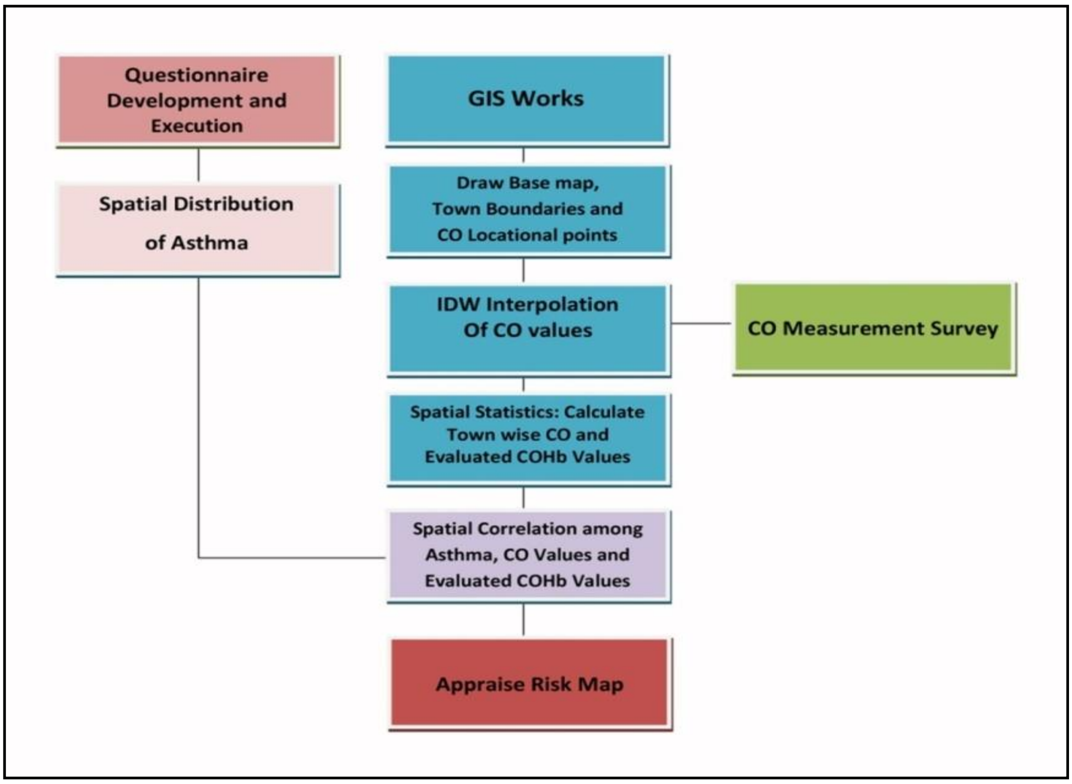


Fig. 2. Flow chart of the study.

Table 1. Values of TWA from ten sites (based on 8 hrs monitoring)

Monitor Sites	Location Surveyed	TWA of CO (ppm)
A	51 C	5
B	Korangi 2 ½	5
C	Korangi Crossing	9
D	Singer Chowrangi	3
E	Murtaza Chowrangi	6
F	Bilal Colony	16
G	Landhi 89	5
H	Muslimabad	7
I	Muzzafarabad	5
J	Brookes Chowrangi	3

Table 2. Health Effects of COHb Blood Level (source: Wayne and Ming-Ho, 2004).

COHb Blood Level (%)	Demonstrated Effects
Less than 1.0	No apparent effects
1.0 to 2.0	Some Evidence of effect on behavioral Performance
2.0 to 5.0	Central Nervous system effects impairment of time interval discrimination, visual acuity, brightness discrimination and certain other psychomotor function.
> 5.0	Cardiac and pulmonary functional change
10.0 to 80.0	Headache, fatigue, drowsiness, coma, respiratory failure, death

Table 3. Spatial Distribution of Asthma Prevalence and CO Values.

ID	UCs	Asthma Prevalence (%)	CO Concentrations (ppm)					Potential COHb Levels (%)*	
			Min	Max	Range	Mean	Std. Deviation	With Mean CO	With Max CO
1	Chakra Goth	0.9	5.55	7	1.45	6.07	0.36	1.47	1.62
2	Mustafa Taj Colony	0.9	5	5.72	0.72	5.34	0.17	1.36	1.42
3	Gulzar Colony	1.1	5.58	8.6	3.02	6.77	0.62	1.58	1.88
4	100 Quarters	0.8	5.23	5.79	0.56	5.55	0.11	1.39	1.43
5	Hasrat Mohani Colony	0.9	5	5.59	0.59	5.32	0.14	1.35	1.39
6	Sector 33	0.6	5	8.85	3.85	6.28	1.04	1.5	1.92
7	Nasir Colony	0.4	3.35	7	3.65	5.92	0.87	1.45	1.62
8	Sherabad	1	3.02	5.32	2.3	4.62	0.61	1.24	1.35
9	Korangi	0.6	4.5	5.45	0.95	5.21	0.18	1.33	1.37
10	Burmese Colony	0.9	4.36	5.37	1.02	5.05	0.22	1.31	1.36
11	Landhi	0.5	5	5.71	0.71	5.34	0.17	1.35	1.41
12	Khawaja Ajmeer Colony	0.2	5.53	6	0.47	5.69	0.12	1.41	1.46
13	Bhutto Nagar	0.9	5	6.04	1.04	5.57	0.27	1.39	1.47

ID	UCs	Asthma Prevalence (%)	CO Concentrations (ppm) Min	Max	Range	Mean	Std. Deviation	Potential COHb Levels (%)* With Mean CO	With Max CO
14	Sharafi Goth	2.5	3.44	8.11	4.67	6.05	0.83	1.47	1.8
15	Moinabad	2.1	5.23	5.72	0.49	5.53	0.11	1.39	1.42
16	Daud Chowrangi	1.3	5.02	7	1.97	5.99	0.47	1.46	1.62
17	Muslim Abad	1.6	5	7	1.99	5.85	0.52	1.44	1.62
18	Muzzafarabad	1.4	5.17	5.61	0.44	5.39	0.11	1.36	1.4
19	Zaman Town	0.3	3.01	7.8	4.79	5.17	0.86	1.33	1.75
20	Bilal Colony	0.6	3	15.99	12.99	8.02	3.45	1.78	3.06
21	Awami Colony	5.1	3.01	15.98	12.98	8.5	3.35	1.86	3.06

* Potential COHb values are estimated with the equation discussed by Wayne and Ming-Ho, 2004
Union councils 1-21 are shown in Fig. 2.

Table 4. Relationship among Asthma Prevalence, CO Concentration and Potential COHb levels.

Variable	Coefficient (r) value
Mean CO Concentration	0.55
Potential COHb Levels with CO Mean	0.56
Maximum CO Concentration	0.51
Potential COHb Levels with CO Max	0.51

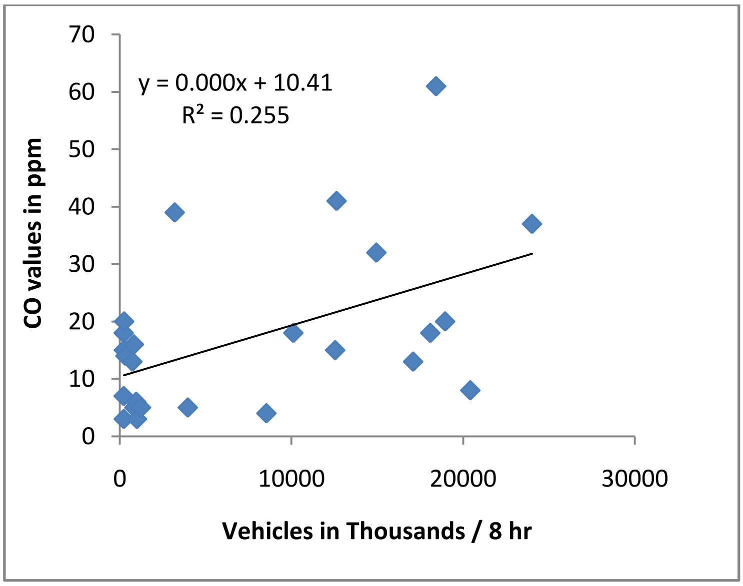


Fig. 3. Traffic Volume and Highest Recorded CO values.

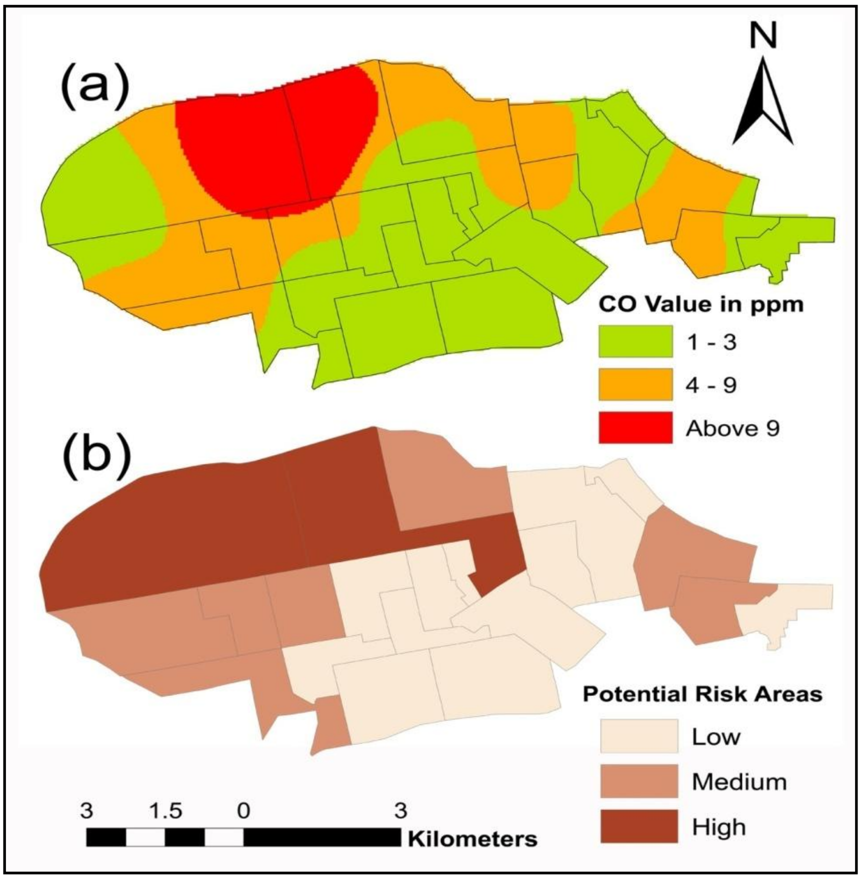


Fig. 4. (a) IDW Interpolated surface of CO 8 hrs values
(b) Potential Risk Areas (Based on Evaluated Spatial COHb Distribution)

Results and Discussion

Table 1 shows Time Weighted Average (TWA) carbon monoxide values for 8 hr, most of the values are within permissible limit by WHO guide line. Highest amount (16ppm) of CO is recorded from Bilal Colony; that is located in northern region of study area. This vicinity is having industries including oil refinery, moreover concentrated transportation as well in this part. Lowest (3ppm) amount of CO was obtained from Singer and Brookes Chowrangi though these sites also in industrial region but in fact garments and other low pollution emitted industries are found here. It is anticipated that long-term exposure to low concentration of CO can also have similar effects to short-term exposure with high concentration. These results are discussing only with Traffic induced while daily life require activities and personal habits like smoking could have more affect on COHb level in body. High CO concentration is mainly due to the lack of regulatory laws of the traffic, so higher amount of CO values were recorded from higher traffic areas and a highly significant relation ($P<0.01$) was obtained between these variables (Fig. 3).

The COHb level in the blood and effects of CO depend on concentration, exposure time, health status of people, their age, and activity (Modic, 2003). CO loading in blood reduces O_2 volume when blood is distributed to body tissues. As a result, the ability of healthy individuals is reduced for physical working and other activities. According to WHO (WHO, 1998; 1999) and American National Standards of ambient air, 8-hr mean concentration of CO gas should not be exceeded from 9 ppm (10, mg/m^3), while our study show that some value reach up to 16 ppm, that is almost 80 % higher than world standards.

Wayne and Ming–Ho, (2004) discussed the demonstrated adverse effects of CO on human health. Table 2, characterizes some effects of COHb Blood Level.2 - 5% blood COHb may affect the central nervous system, impair time interval discrimination, cause visual acuity, affect discrimination of brightness and may change certain other psychomotor functions. When this situation is supplemented with other gaseous pollutants of automobile exhaust and open burning such as hydrocarbons, oxides of sulphur and nitrogen oxides, an adverse picture can be visualized.

Asthma controlling factors that start asthma attack by worsening the inflammation in the airways. Spatial distribution of asthma prevalence is linked with the distribution and intensity of asthma controlling factors (Maantay, 2007). In our results, prevalence of asthma is spatially variable. The considerably high values are found in Awami Colony and Sharafi Goth. Table 3 shows the UC wise distribution of asthma prevalence, CO concentrations (viz. minimum, maximum, range, mean and standard variation) and potential COHb levels. CO concentration values were summarized illustration of Fig. 4(a), which was obtained through GIS. Estimated COHb levels by using CO mean values are estimated from 1.24 % (UC Sherabad) to 1.86 % (UC Awami colony) while with CO maximum values these are from 1.4 % (UC Muzzafarabad) to 3.06 % (UCs Bilal Colony and Awami Colony).

Table 4 demonstrates the association among UC wise asthma prevalence, CO concentration (maximum and mean) and potential COHb levels (with CO maximum and mean values). Significant relationship has been observed among all these variables that indicate high CO concentration is potentially harmful for asthma patients (Hampson and Hauff, 2008; Owens, 2010; Sahara *et al.*, 2010). In view of this relationship, Fig. 4(b) shows the potential risk areas. It is suggested that some environmental measures should be undertaken that would reduce the CO concentration levels and ultimately would help out to reduce its effects including asthma.

Conclusion

GIS based study shows that the asthma prevalence and carbon monoxide and evaluated COHb values are strongly correlated, which means the higher the CO levels the higher the Asthma prevalence. The concentration of carbon monoxide in the ambient air on the busy roads of the study area is high. The high pollution level of Landhi and Korangi is mainly due to automobile exhaust is causing a rise in the occurrence of asthma, other respiratory and heart related diseases. It is also seen that GIS with allied technology is a useful tool to point out disease risk areas.

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