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Research Article

Antioxidant and Systemic Symptoms Evaluation in Areas with Different Air Pollution Levels

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Abstract

Background: The WHO has identified ambient air pollution as a high public health priority. The community health research programs that were performed by Tikrit University College of Medicine have estimated that more than a fourth of Iraqi populations were presented with illnesses which may be due environmental etiology.

Objective: Investigate whether outdoor air pollution associated with oxidative stress.

Methodology: Study field divided in to four regions [A, B, C and D] according to pollution density. Area D represents the control area. Concentration of toxic gases in the air was determined using MIR9000 instrument.. Concentration of particulate matters in the air was determined using BETA5M instrument. Sub indices of SO_2, NO_2, CO, O_3, PM and H_2S were determined from their concentrations in air. Then these indices aggregated to yield an overall air pollution index. To clarify oxidative stress association with indoor air pollution, 50 blood and urine samples were collected from polluted (A, B, C] and control areas for determination of Malondialdehyde, Total Antioxidant Capacity 8-hydroxydeoxyguanosine (8-OHdG).

Results: Air pollution was a higher risk factor for development of eye symptoms and lower for airway symptoms. Urinary 8-OHdG, serum malondialdehyde (MDA), and total antioxidant capacity (TCA) concentrations were significantly related to number of SBS/SHS symptoms. There was a highly significantly correlation between visual analogue scale for each symptom type and their frequency, aggregated pollution indices of the pollutants, sub indices of pollutants, oxidative biomarkers.

Conclusion: Air pollution was with impact on individuals' health and the effect was correlated to concentration of pollution.

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- Antioxidant
- Malondialdehyde
- Respiratory symptoms
- Kirkuk

INTRODUCTION

Indoor and outdoor air pollution is one of the most serious environmental and public health problems in the industrialized world [1]. Epidemiological evidence supports an association between exposure to ambient air pollutants and various health effects, such as respiratory symptoms or illness impaired cardiopulmonary function, reduction of lung function, and premature mortality [2-7]. Air pollution has more serious effects on high risk groups especially children, elderly people and individuals suffering from heart or lung diseases [8-12]. Although ambient air quality has important implications for health, indoor air quality is also a major concern since people spend much more time indoors. Exposure of adolescents to indoor air pollutants is mainly determined by concentrations of pollutants in three microenvironments: home, school and transport [13,14].

Major sources of pollutants measured indoors are derived from outdoor activities (traffic, industry, combustion, *etc.*), human activities inside (cooking, painting, cleaning, *etc.*), building equipment and furnishings. On the other hand, it is not easy to assess the air pollution status at fine spatial resolution in large geographical areas due to the prohibitive costs and manpower resources necessary for the measurement and monitoring of pollutants [15]. Air pollutant concentrations are relatively high in densely populated congested locations in a city which means that exposure of people to those pollutants is expected to be higher compared to people living in less polluted

locations [16]. Preliminary information about pollutant spatial distribution in a geographical area is essential for identifying the risk to populations in a certain region. Geographical Information Systems (GIS) as a tool may provide help for the assessment of polluted and unpolluted sites by using pollutant concentrations measured at specific locations. Another point of interest in air pollution studies is the simultaneous measurement of pollutants at multiple locations by use of proper sampling devices. Passive samplers which are inexpensive, do not require electricity and easy to operate have been used for indoor and outdoor air quality assessment purposes [17,18].

Exposure to air pollution from industrial and traffic sources is one of the most important public health problems. The intersection between air quality, student's health and schools has also attracted the interest of many researchers and activists [19]. Adolescents may be particularly susceptible to the adverse effects of air pollution because they have a larger surface area and breathe more air per kilogram body weight than adults [20,21]. In this study, students living in Kirkuk, an industrial area showed higher rates of respiratory system symptoms (physician diagnosed chronic pulmonary disease, tightness in chest and morning cough without infection). These findings indicate that air pollution in the industrial areas is a risk factor in the prevalence of respiratory system symptoms and this is consistent with the results of other authors [22,23]. This study was conducted to Investigate whether outdoor air pollution associated with oxidative stress.

MATERIALS AND METHODS

Study population

The study conducted in Kirkuk City. The study field divided in to four regions [A,B,C and D] according to pollution density. Area D represent the control area. Concentrations of toxic gases in the air were determined using MIR9000 instrument from Fox boro Company [Multigasanalyser by GFC infrared]. Concentrations of particulate matters in the air were determined using BETA5M instrument. Sub indices of SO_2, NO_2, CO, O_3, PM and H_2S were determined from their concentrations in air. Then these indices aggregated to yield an overall air pollution index. The sub indices were expressed as linear functions of ratio of pollutant concentration to the standard concentration by using data reported elsewhere [24].

Symptom score

A 10 cm visual analogue scales from 0=absent to 10=sever symptoms, for each symptom related to general, skin, eye, respiratory symptoms (Rhinorrhoea, nasal congestion, nasal itching, sneezing, chest tightness, shortness of breath, cough, and wheezing as recommended by the ARIA review [25]. A change of 2 or more points on this scale is considered a clinically significant change with consequent significant change in the patient quality of life. The information regarding health status of participants were collected through interview according to pre designed questionnaire prepared for this research. Then complete physical examination to be performed by consultant physician. Data reported for study population came from two questions asked about 20 symptoms related to respiratory system, skin, eye and general health of the participant.

Oxidative stress associated with indoor air pollution

A 50 blood and urine samples were collected from polluted (A, B, C) and control areas. Serum separated and used for determination of Malondialdehyde (oxidant marker) and Total Antioxidant Capacity (as antioxidant marker). The urine samples were used for determination of 8-hydroxydeoxyguanosine (8-OHdG).

Determination of 8-OHdG

Urinary 8-OHdg levels were determined by OXIS Research Enzyme Linked Immunosorbent Assay kit. At room temperature, 50 µl of 8-OHdG monoclonal and 50 µl of each urine sample or standard solution were loaded onto a microplate [26]. The determination ranged from 0.5 to 200 ng/ml, expressed as microgram per gram creatinine.

Determination of MDA

As index of lipid peroxidation, serum MDA concentration was determined by measuring the thiobarbituric acid reactive substances (TBARS) according to the Spectrophotometric method of Janero [27].

Determination of TAC

The materials used in the determination of TAC in serum were a gift from Dr. V. Tsaousis, Medicon Hellas SA, Gerakas, Greece. They include, 2, 2- Azobis-(2-amidinopropane) dihydrochloride (ABAP), 6- hydroxyl-2, 5, 7, 8-tetramethylchromane-2-carboxylic acid (Trolox C) from Sigma- Aldrich. ABAP was dissolved just before use with a 10 mM phosphate buffer (pH 7.4) at a concentration of 5 mg / ml. Crocin was from the association of Saffron producers, Krokos, Kozani, Greece- Crocin stock solution was prepared in a phosphate buffer (10 mM, pH 7.4) at concentration of 20 uM with buffer. The method for serum TAC determination was as previously described by Kampa M *et al*. [28].

Statistical analysis

Student t test was used to compare mean values of visual analogue scale, 8-OHdG, MDA, and TAC between the study groups. Chi square test was used for comparison of frequency between the study areas. P value of < 0.05 considered as significant. The analysis was performed using SPSS (version 16). Logistic regression line analysis was used to determine the association between air pollution and skin, respiratory, eye and general symptoms.

RESULTS

Table 1 shows the frequency of systematic symptoms in areas with different air pollution concentration. Dermal symptoms were increased significantly with the increase of air pollution (P=0.001). The symptoms were lower in area D (8%), the area of lower air way pollution, as compared to areas C (20.4%), B (24.3%) and A (30.8%). Airway symptoms frequency was significantly related to air pollution concentration (P=0.001). Airway symptoms was higher in area A (55%), the area of higher air pollution, and lower in area D (21.9%) of lower air pollution.

Eye symptoms were reported in 32.8% of area C , 39.9% of area B, 49.1% of area A and 11.3% of area D. The frequencies

of eye symptoms were increased with the increase of air pollution concentration. The differences in frequency of eye symptoms between the areas with different air pollution were highly significant (P=0.001). General symptoms increased with the increase of air pollution, but their frequency was higher as compared to eye, airway, and dermal symptoms for all the 3 polluted areas (P=0.01), Table 1.

The visual analogue scales [VAS] of symptoms in the areas with different air pollution are shown in Table 2. The mean visual analogue scale was low (2.3) in area D (the control area with lower air pollution). However, it was higher in area with higher air pollution (area A, visual analogue scale =8.8). There was a steady increase in visual analogue scale with the increase of air pollution for dermal, airway, eye and general symptoms. In addition, visual analogue scale was higher for general symptoms (P<0.05) in area D (Control area). While area with higher air pollution (area A), a higher visual analogue scale was demonstrated by eye (VAS=9.1) and dermal (VAS=9.0) symptoms, but the differences between symptom types were statistically not significant. In area B, the higher VAS was that of general symptoms (VAS=7.6), while the higher one in area C was that of eye symptoms (VAS=6.1).

Table 3 shows the odd ratios of different symptoms. Air pollution was a significant risk factor for development of dermal (OR=3.97; P=0.001), air way (OR=3.05; P=0.001), eye (OR=5.52; P=0.0001) and general (OR=4.97; P=0.001) symptoms. The overall odd ratio for combined symptoms was 6.7 with highly significant (P=0.0001) value. Furthermore, air pollution was a higher risk factor for development of eye symptoms (OR=5.52) and lower for airway symptoms (OR=3.05).

Table 4 shows that urinary 8-OHdG, serum malondialdehyde (MDA), and total antioxidant capacity (TCA) concentrations were significantly (P=0.01) related to number of SBS/SHS symptoms. For MDA, serum mean level for subjects free of SBS/SHS symptoms was 3.71 ±1.93µmol/l. This value increased with increase of symptom number, thus it reach value of 9.81±4.53µmol/l in individuals with ≥5 symptom number. The mean serum TAC

Table 1: Frequency of systematic symptoms in areas with different air pollution concentration.

Symptoms	Area C No.[%]	Area B No.[%]	Area A No.[%]	Area D No.[%]	P value
Number	137	148	169	151	
Dermal	28 [20.4]	36 [24.3]	52 [30.8]	12 [8.0]	0.001
Airway	49 [35.8]	67 [45.3]	93 [55.0]	33 [21.9]	0.001
Eye	45 [32.8]	59 [39.9]	83 [49.1]	17 [11.3]	0.001
General	60 [43.8]	76 [51.4]	110 [65.1]	29 [19.2]	0.001

Table 2: Visual analogue scale of symptoms in areas with different air pollution concentration.

Symptoms	Area C Mean [SD]	Area B Mean [SD]	Area A Mean [SD]	Area D Mean [SD]	P value
Dermal	5.8 [1.97]	6.9 [2.32]	9.0 [2.15]	1.9 [0.97]	0.001
Airway	4.9 [1.65]	6.3 [1.66]	8.4 [3.10]	2.3 [0.87]	0.001
Eye	6.1 [2.21]	7.3 [2.81]	9.1 [2.96]	2.0 [0.68]	0.001
General	5.6 [1.70]	7.6 [2.31]	8.7 [1.92]	3.1 [1.04]	0.001
Mean	5.6	7.0	8.8	2.3	0.001

Table 3: Odd ratio of different symptoms.

Symptoms	Reference area Ever /Never [%]	Polluted area Ever /Never [%]	Odd ratio [95% confidence interval]	P value
Dermal	12/139 [8]	116/338 [25.6]	3.97 [2.13- 7.44]	0.001
Airway	33/118 [21.9]	209/245 [46]	3.05 [1.99- 4.68]	0.001
Eye	17/134 [11.3]	187/267 [41.2]	5.52 [3.22 – 9.45]	0.0001
General	29/122 [19.2]	246/208 [54.2]	5.05 [3.19- 7.76]	0.001

Table 4: Mean [SD] of Malondialdehyde (MDA), Total Antioxidant Capacity (TAC) and 8-Hydroxydeoxyguanosine [8OHdG] according to numbers of Sick Building Syndrome symptoms.

Number of symptom	Mean [SD]		
	MDA µmol/l	TAC µmol/l	8OHdG µg/g creatinine
0	3.71 [1.93]	1032 [260]	5.65 [3.17]
1 – 4	4.75 [2.13]	879 [166]	6.11 [4.12]
≥ 5	9.81 [4.53]	783 [113]	9.01 [3.57]
P value	0.01	0.01	0.01

value was 1032 ± 260 in group of subjects free of SBS/SHS symptoms, while it reduced to 783±113 in group of subjects with ≥5 symptom number. Urinary 8OHdG concentration mean value increased from 5.65 ±3.17 µg/g creatinine in group of individuals free of SBS/SHS symptoms to 9.01 ±3.57 µg/g creatinine group of subjects with ≥5 symptom number.

Total antioxidant capacity mean serum value significantly lower (P=0.001) in air polluted areas (837±110) as compared reference area (949±147). In addition, MDA mean serum value was highly significantly (P=0.000) higher in polluted areas (8.37±3.75 µmol/l) as that in reference area (2.73 ±1.93 µmol/l). Furthermore, urinary 8OHdG mean value was highly significantly (P=0.0001) lower in reference area (3.83±1.21 µg/g creatinine) as compared to air polluted areas (8.74±4.35 µg/g creatinine), Table 5.

Correlation between symptoms frequency and visual analogue scale

There was a highly significantly (0.000) correlation between visual analogue scale for each symptom type and frequency of dermal (R^2 =0.99), airway (R^2 =0.99), eye (R^2 =0.99) and general (R^2 =0.96) symptoms. Figures 1-4.

Correlation between visual analogue scale and aggregated air pollution index

Mean VAS was with highly significantly correlation with aggregated air pollution index calculated with addition of H_2S sub index (Figure 5). In addition, when the aggregated air pollution index was calculated without adding H_2S sub index, it was with a significant correlation with VAS (Figure 6).

Correlation between mean visual analogue scale and symptoms frequency

The mean VSA [mean of dermal, airway, eye and general analogue scale] was highly significantly correlated to dermal, airway, eye and general symptoms (Figures 7-10).

Correlation between aggregated air pollution index and symptoms frequency

Aggregated air pollution index was with significant correlation with dermal (R^2 =0.99), airway (R^2 =0.99), eye (R^2 =0.98) and general (R^2 =0.98) symptoms frequency (Figures 11-14). In addition, when the aggregated air pollution index calculated excluding H_2S sub index, the index shows a significant correlation with dermal (R^2 =0.94), airway (R^2 =0.98), eye (R^2 =0.95) and general (R^2 =0.94) symptoms frequency (Figures 15-18).

Table 5: Mean [SD] Malondialdehyde (MDA), Total Antioxidant Capacity (TAC) and 8-Hydroxydeoxyguanosine [8OHdG] in polluted compared to non-polluted areas.

Variable	Mean [SD]		
	Polluted areas	Reference area	P value
MDA	8.37 [3.75]	2.73 [1.93]	0.0001
TAC	837 [110]	949 [147]	0.001
8OHdG	8.74 [4.35]	3.83 [1.21]	0.0001

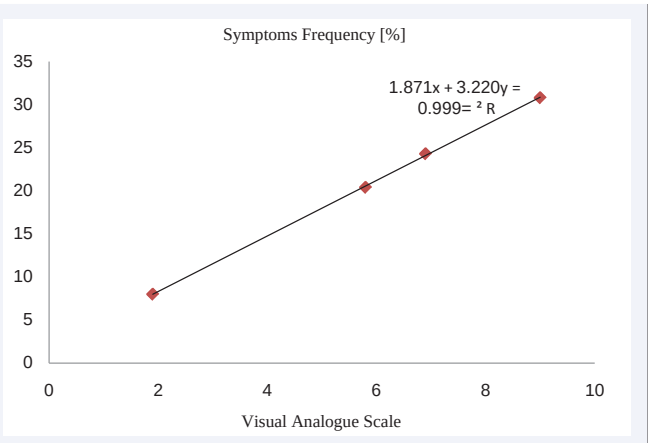

Figure 1 Correlation between Dermal Visual Analogue Scale (VAS) and frequency of dermal symptoms.

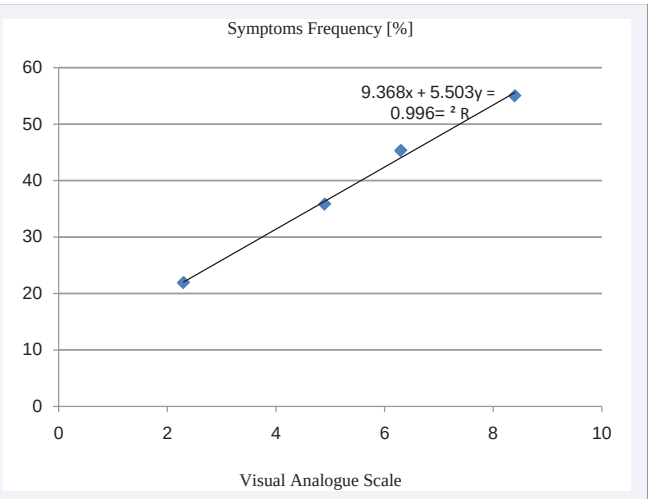

Figure 2 Correlation between airway Visual Analogue Scale (VAS) and frequency of airway Symptoms.

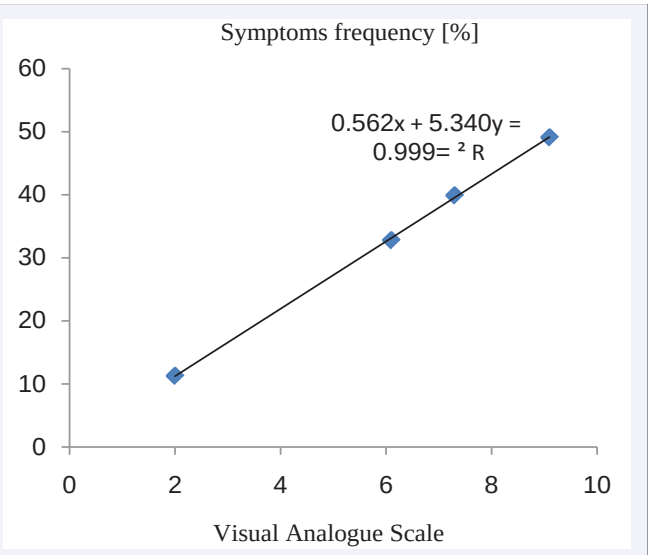

Figure 3 Correlation between eye Visual Analogue Scale (VAS) and frequency of eye symptoms.

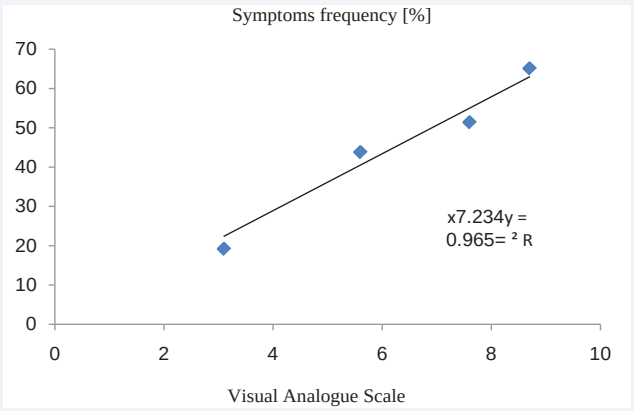

Figure 4 Correlation between general Visual Analogue Scale (VAS) and frequency of general symptoms.

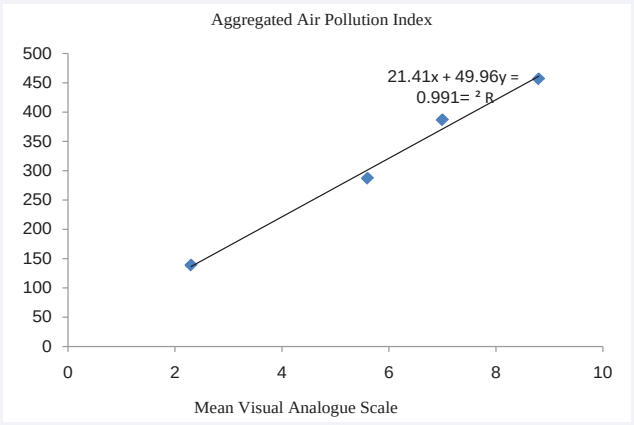

Figure 5 Correlation between mean visual analogue scale and aggregated pollution index [with H_2S].

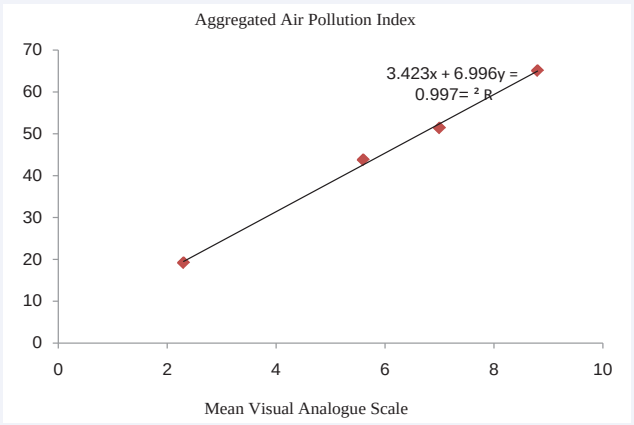

Figure 6 Correlation between mean visual analogue scale and aggregated pollution index [without H_2S].

Correlation between symptoms frequency and air pollution sub indices

SO_2 sub indices show a highly significantly correlation with dermal (R^2 =0.87), airway (R^2 =0.92), eye (R^2 =0.84) and general (R^2 =0.88) symptoms frequency (Figures 19-22). NO_2 sub indices were with highly significantly correlation with dermal (R^2 =0.95), airway (R^2 =0.99), eye (R^2 =0.94) and general (R^2 =0.95) symptoms frequency (Figures 23-26). Carbon monoxide sub indices were significantly correlated with dermal (R^2 =0.67), airway (R^2 =0.74), eye (R^2 =0.63) and general (R^2 =0.68) (Figures 27-30).

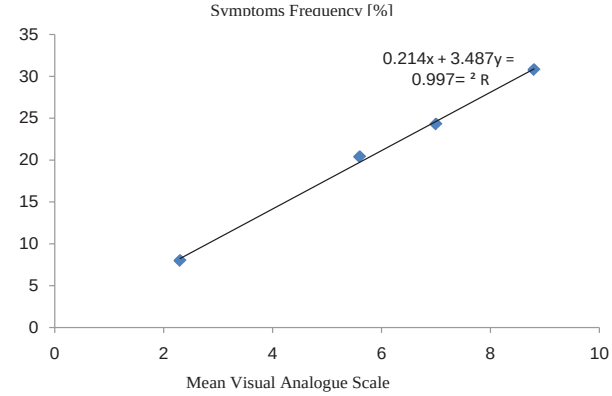

Figure 7 Correlation between mean visual analogue scale and dermal symptoms.

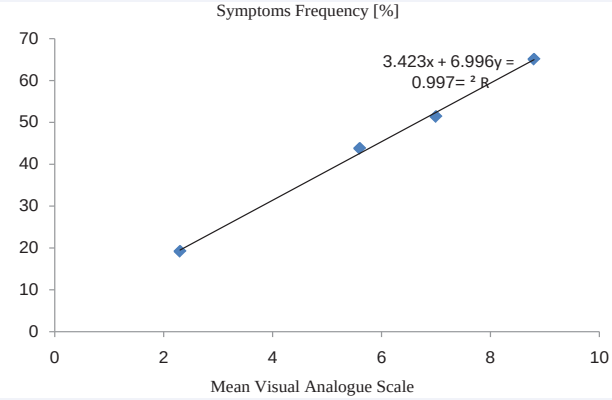

Figure 8 Correlation between mean visual analogue scale and airway symptoms.

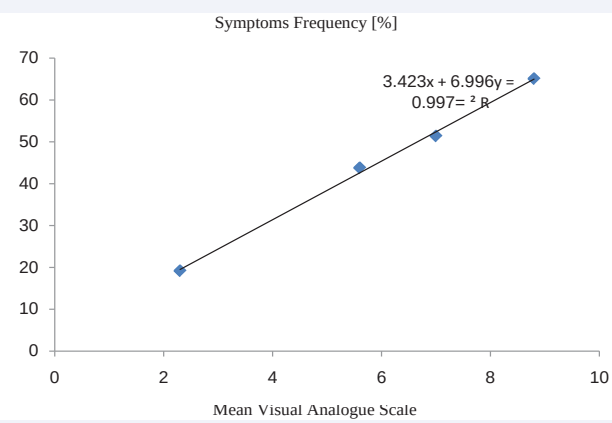

Figure 9 Correlation between mean visual analogue scale and eye symptoms.

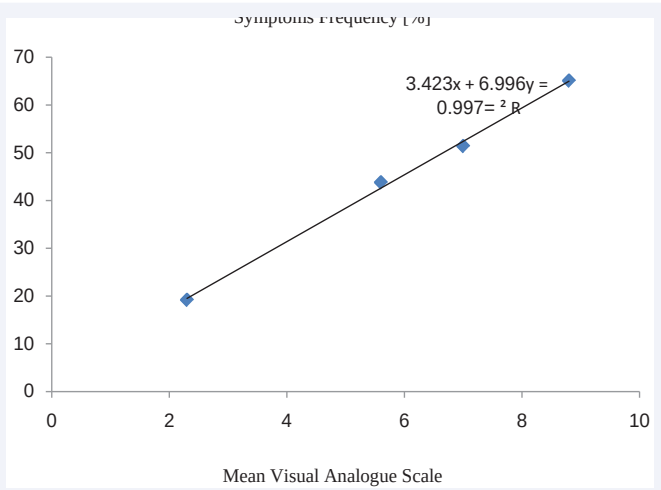

Figure 10 Correlation between mean visual analogue scale and general symptoms.

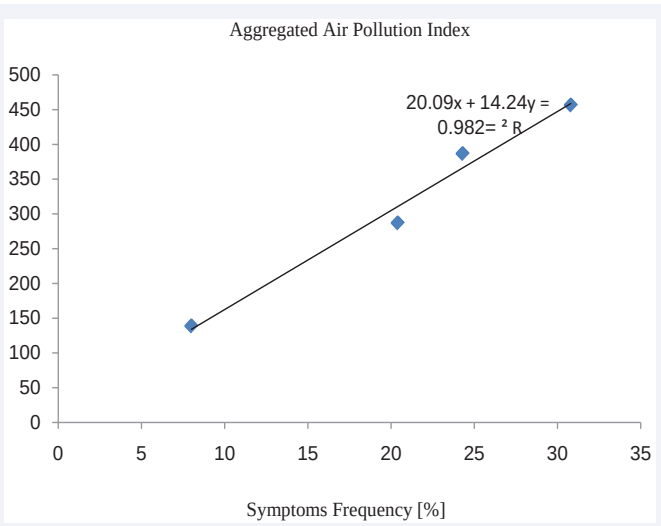

Figure 11 Correlation between aggregated air pollution index [with H_2S] and dermal symptoms .

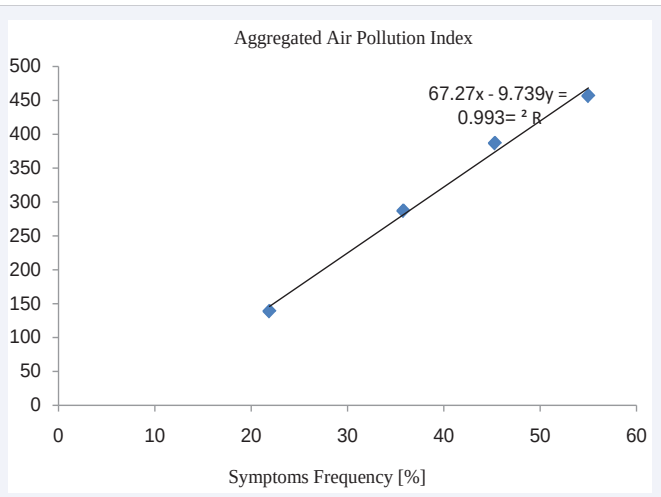

Figure 12 Correlation between aggregated air pollution index [with H_2S] and airway symptoms frequency.

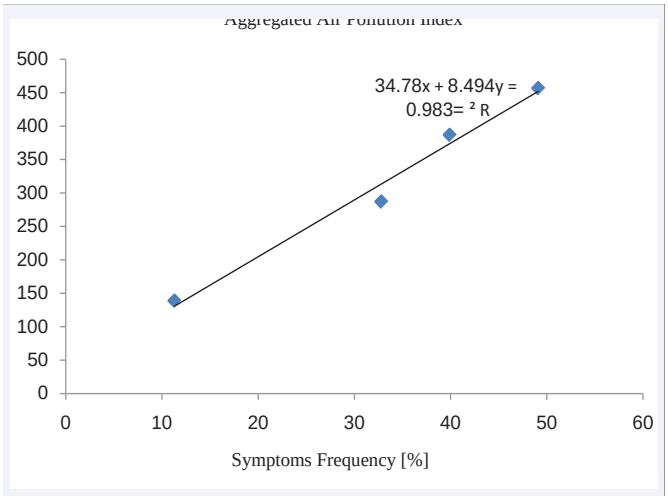

Figure 13 Correlation between aggregated air pollution index [with H_2S] and eye symptoms frequency.

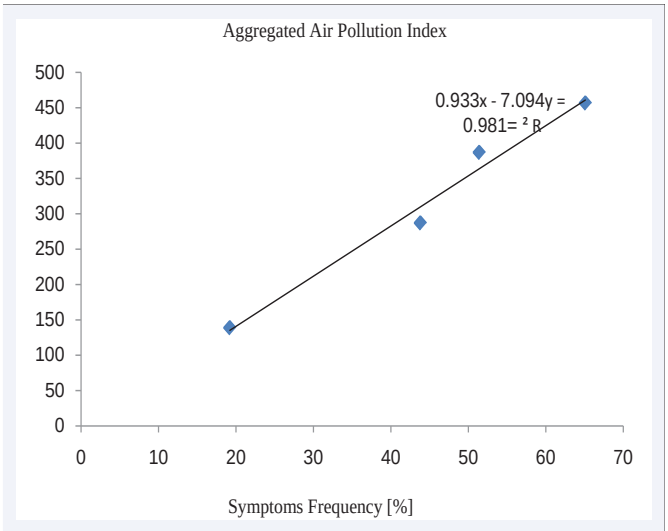

Figure 14 Correlation between aggregated air pollution index [with H_2S] and general symptoms frequency.

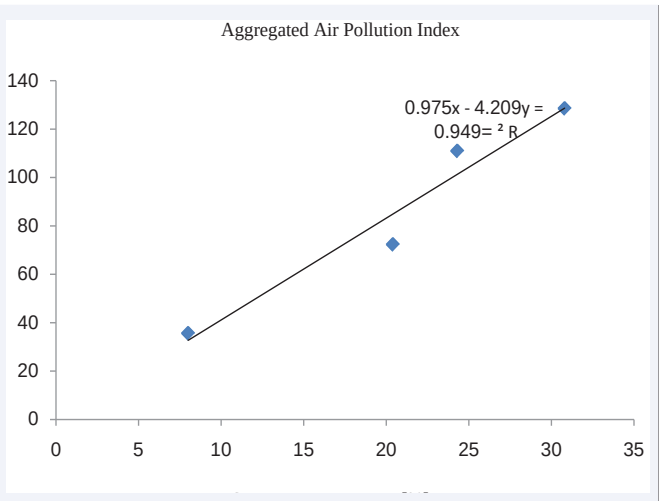

Figure 15 Correlation between aggregated air pollution index [without H2S] and dermal symptoms.

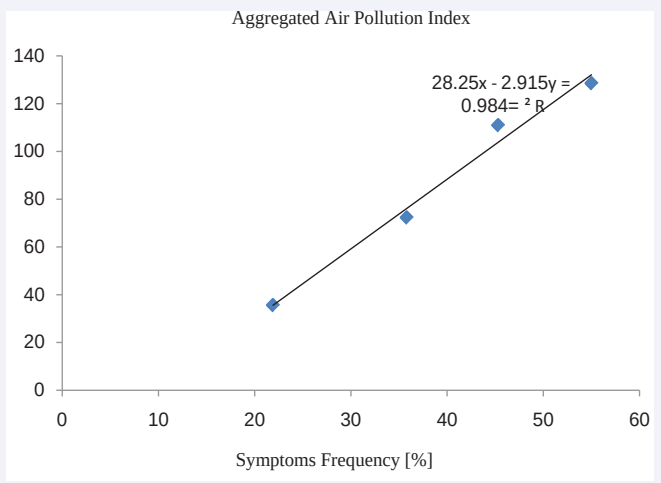

Figure 16 Correlation between aggregated air pollution index [without H_2S] and airway symptoms.

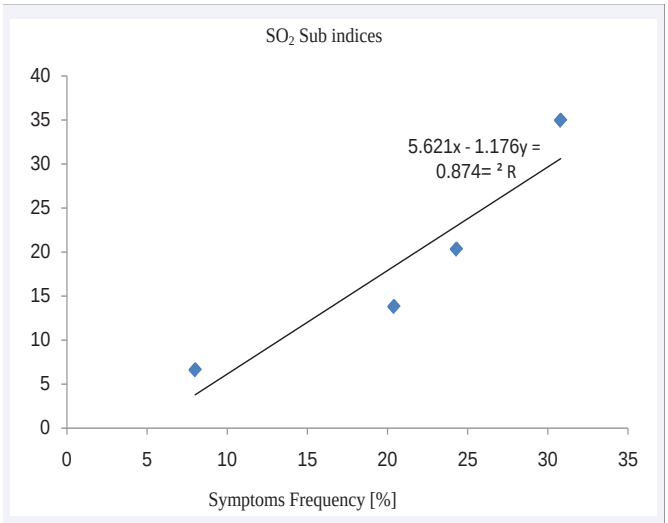

Figure 19 Correlation between SO_2 sub indices and dermal symptoms.

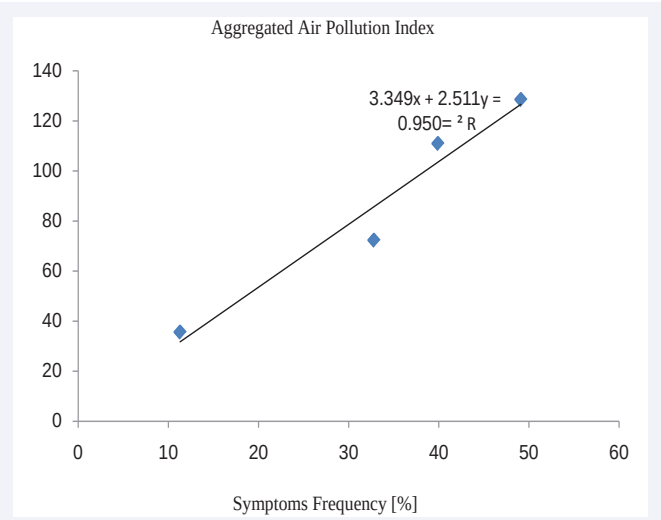

Figure 17 Correlation between aggregated air pollution index [without H_2S] and eye symptoms.

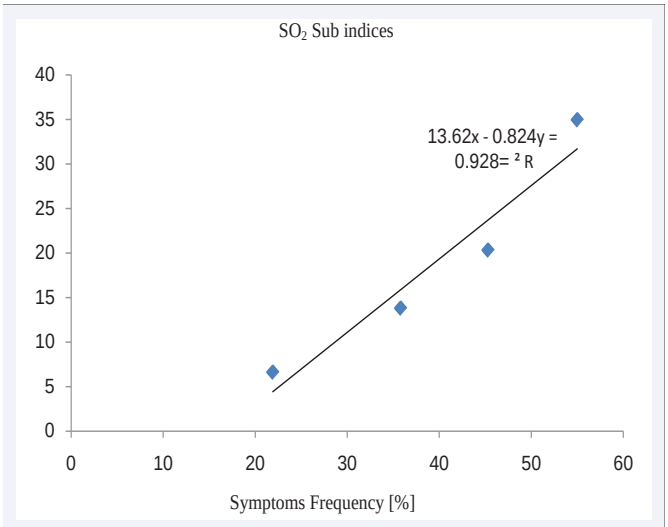

Figure 20 Correlation between SO_2 sub indices x and airway symptoms.

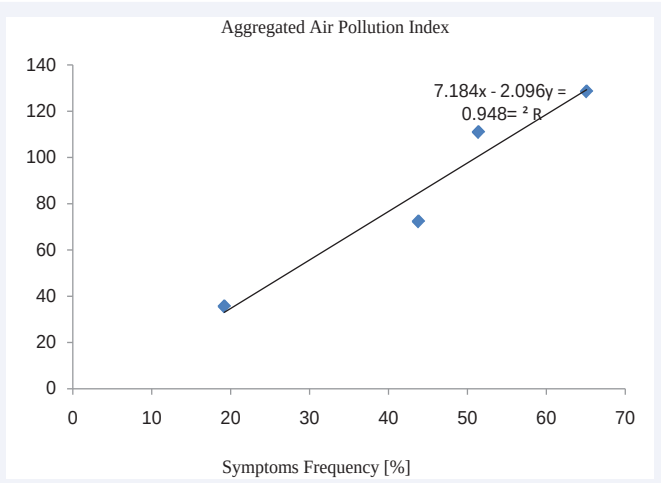

Figure 18 Correlation between aggregated air pollution index [without H_2S] and general symptoms.

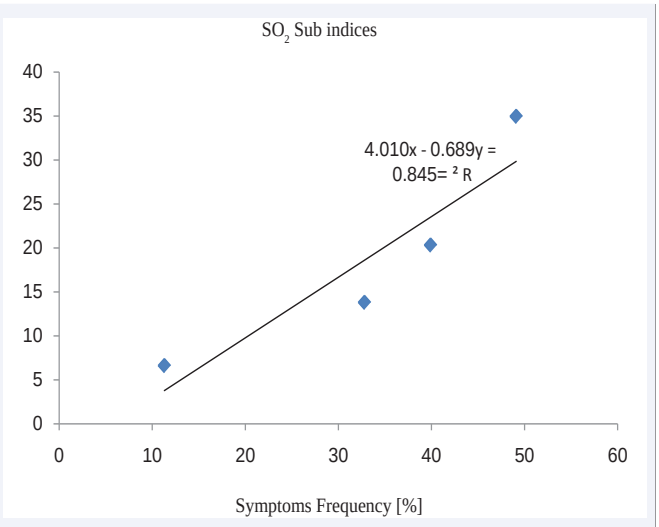

Figure 21 Correlation between SO_2 sub indices and eye symptoms.

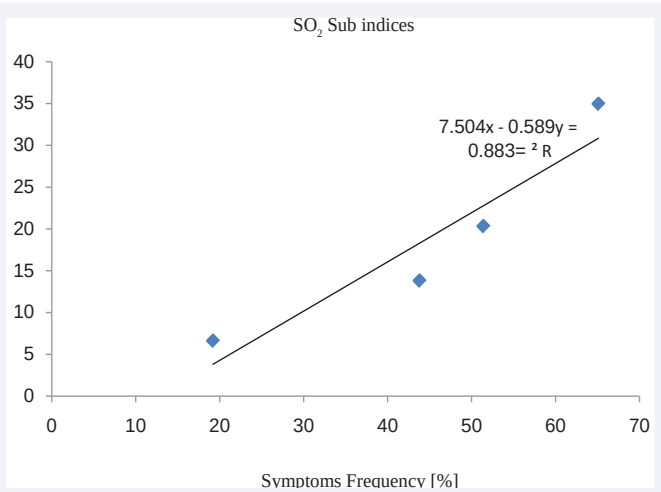

Figure 22 Correlation between SO2 sub indices and general symptoms.

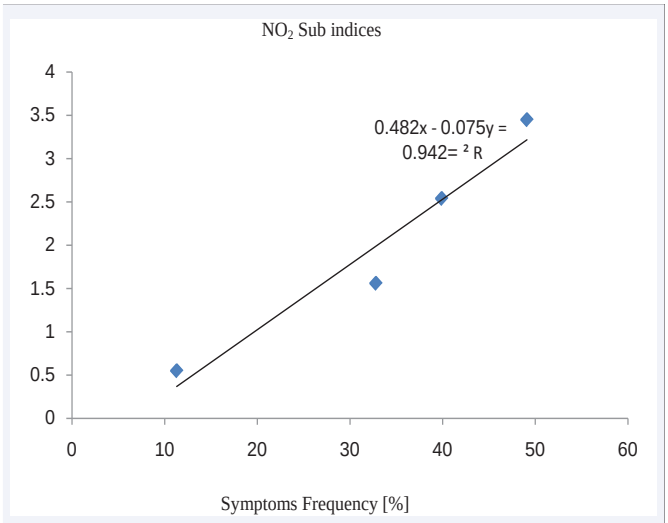

Figure 25 Correlation between NO_2 sub indices and eye symptoms.

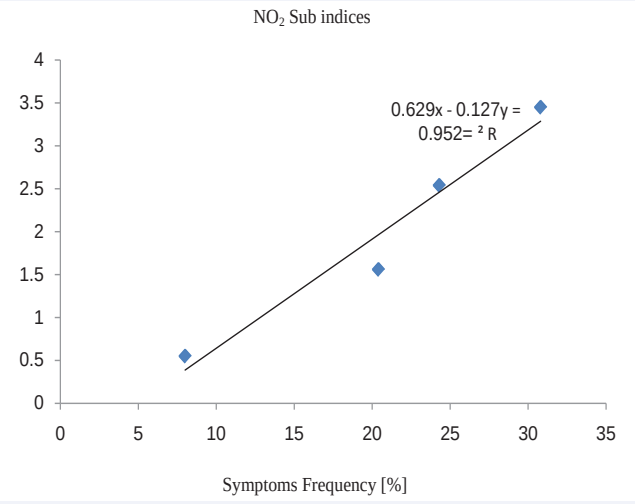

Figure 23 Correlation between NO_2 sub indices and dermal symptoms.

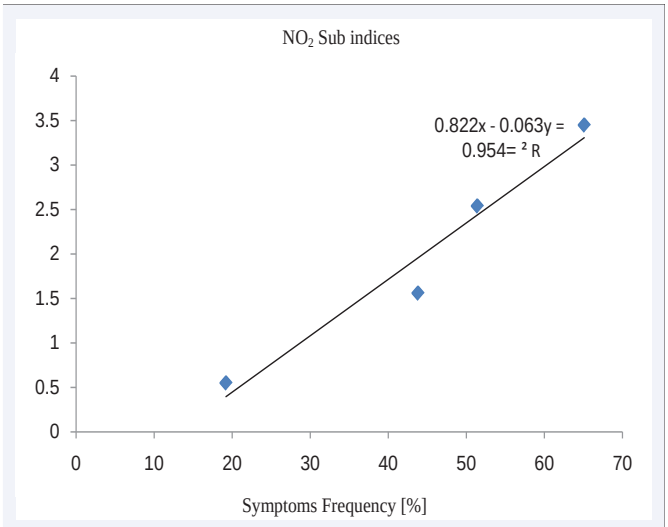

Figure 26 Correlation between NO_2 sub indices and general symptoms.

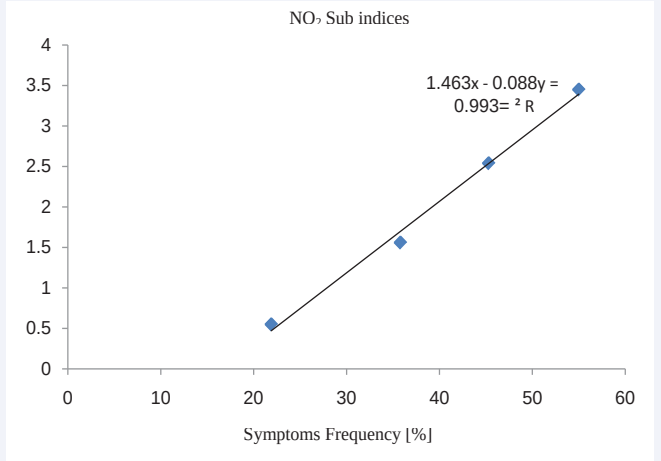

Figure 24 Correlation between NO_2 sub indices and airway symptoms.

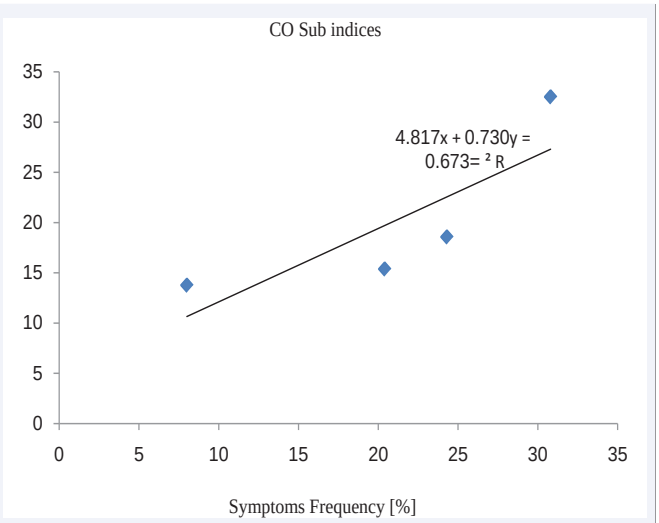

Figure 27 Correlation between CO sub indices and dermal symptoms.

Ozone sub indices were with significant correlation to dermal (R^2 =0.88), airway (R^2 =0.95), eye (R^2 =0.88) and general (R^2 =0.88) symptoms frequency (Figures 31-34). Particulate matter sub indices were correlated significantly to dermal (R^2 =0.88), airway (R^2 =0.98), eye (R^2 =0.96) and general (R^2 =0.95) symptoms frequency (Figures 35-38). H_2S sub indices were correlated significantly to dermal (R^2 =0.98), airway (R^2 =0.99), eye (R^2 =0.98), and general (R^2 =0.98) symptoms frequency (Figures 39-42).

Correlation between mean visual analogue scale and oxidants/ antioxidants biomarkers

Serum MDA was significantly correlated to mean VAS of symptoms (R^2 =0.92) (Figure 43). In addition, serum TAC was with significant inverse correlation with VSA of symptoms (R^2 =0.94). (Figure 44). Furthermore, 8OHdg urinary concentration was significantly correlated (R^2 =0.87) to VAS of symptoms (Figure 45).

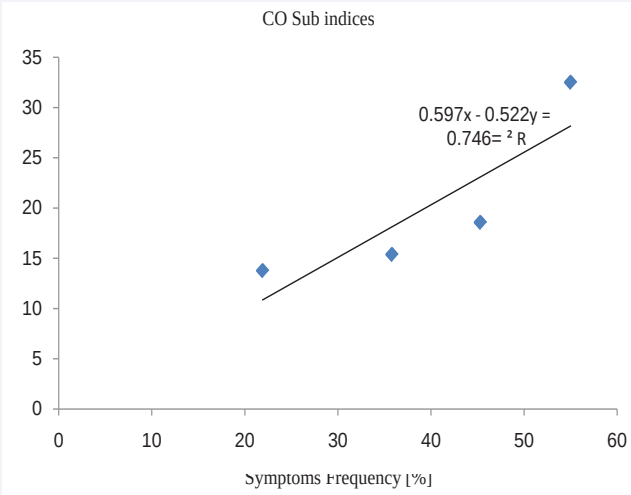

Figure 28 Correlation between CO sub indices and airway symptoms.

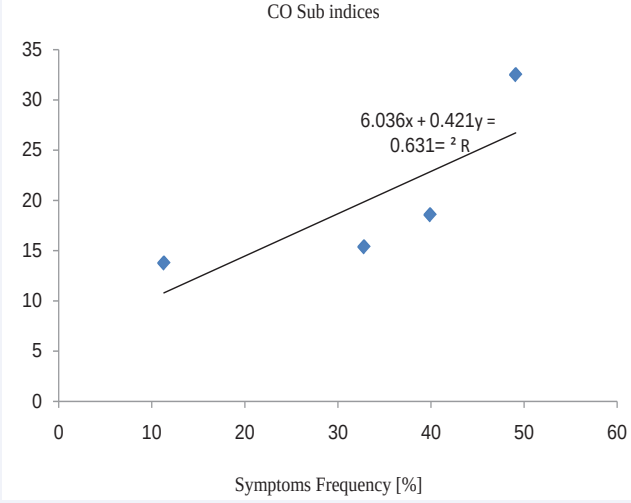

Figure 29 Correlation between CO sub indices and eye symptoms.

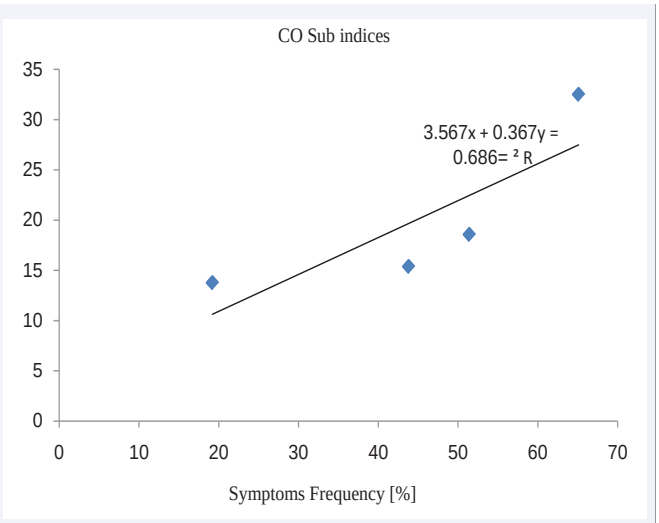

Figure 30 Correlation between CO sub indices and general symptoms.

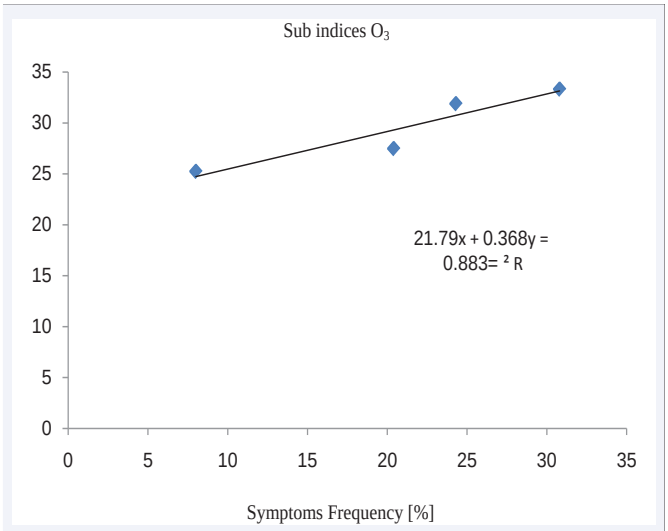

Figure 31 Correlation between O_3 sub indices and dermal symptoms.

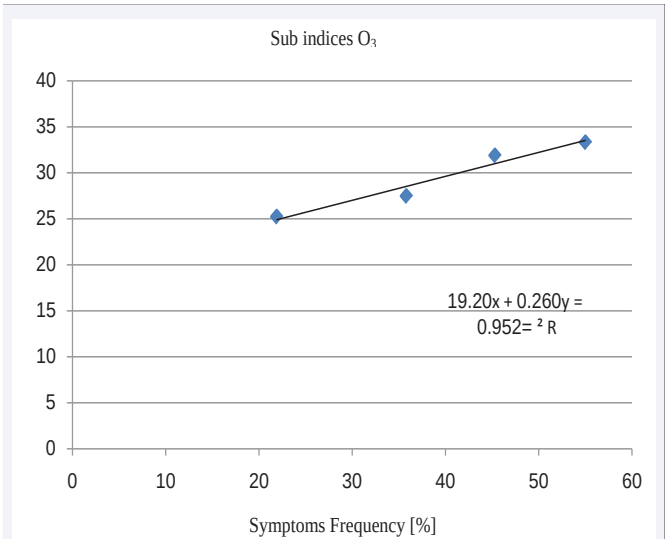

Figure 32 Correlation between O_3 sub indices and airway symptoms.

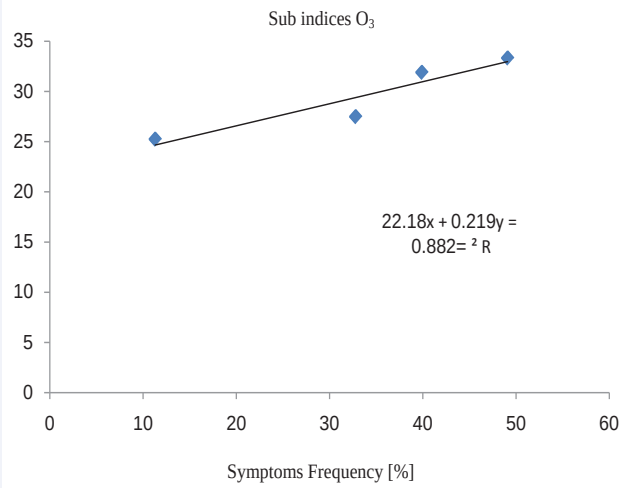

Figure 33 Correlation between O_3 sub indices and eye symptoms.

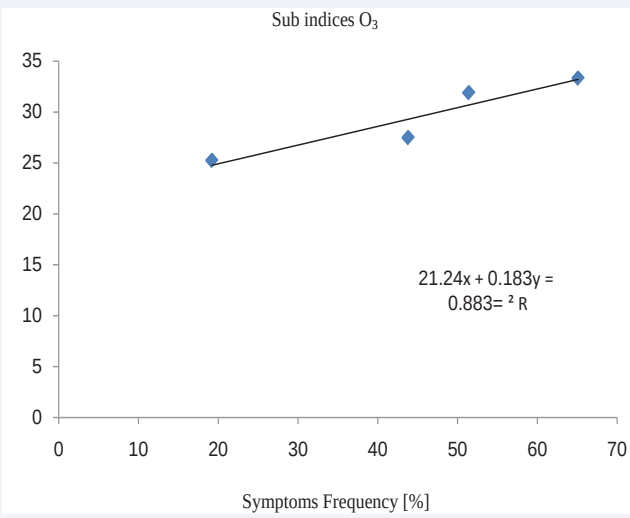

Figure 34 Correlation between O_3 sub indices and general symptoms.

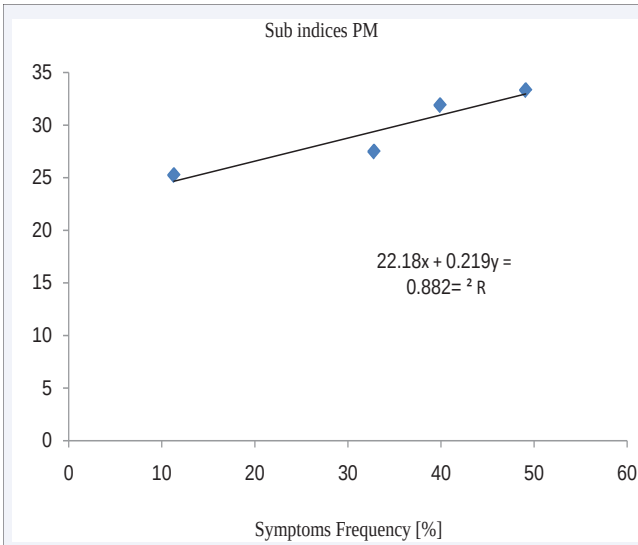

Figure 35 Correlation between PM sub index and dermal symptoms.

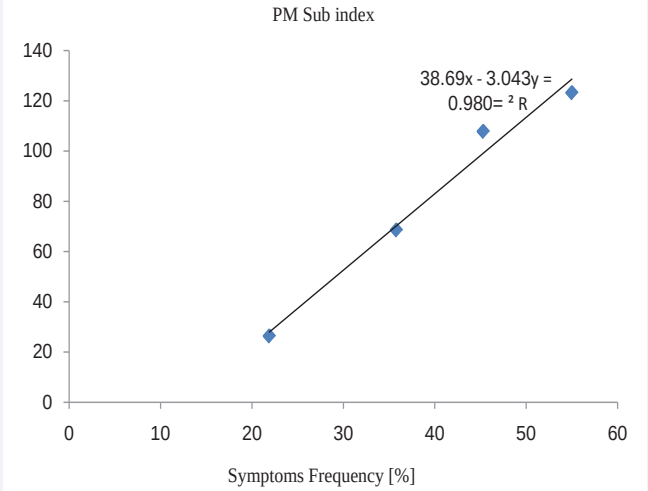

Figure 36 Correlation between PM sub index and airway symptoms.

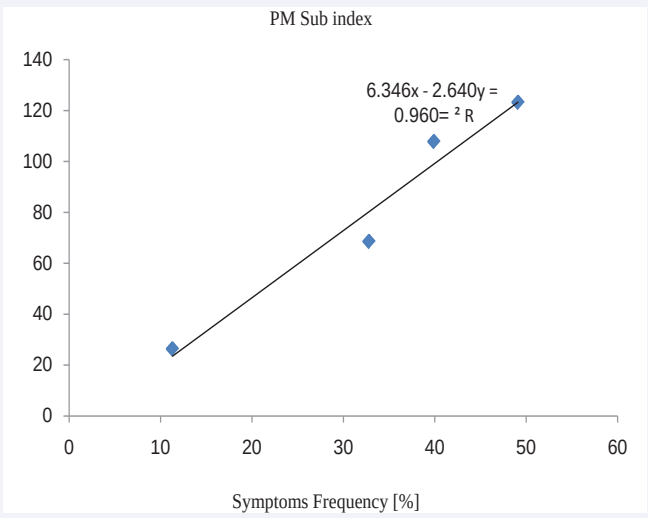

Figure 37 Correlation between PM sub index and eye symptoms.

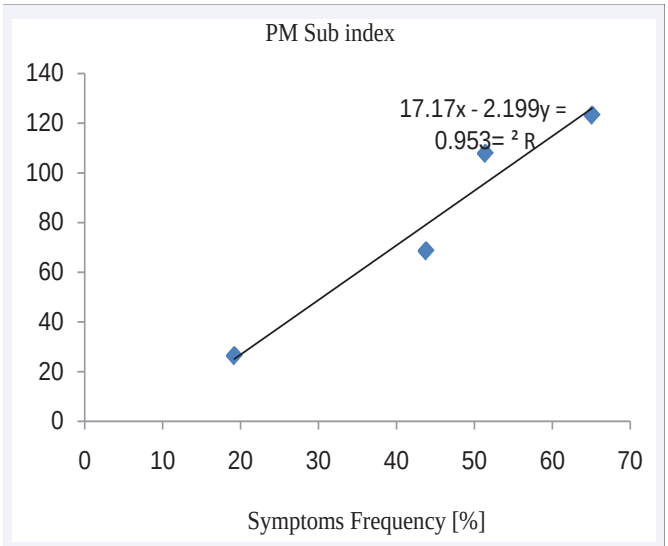

Figure 38 Correlation between PM sub index and general symptoms.

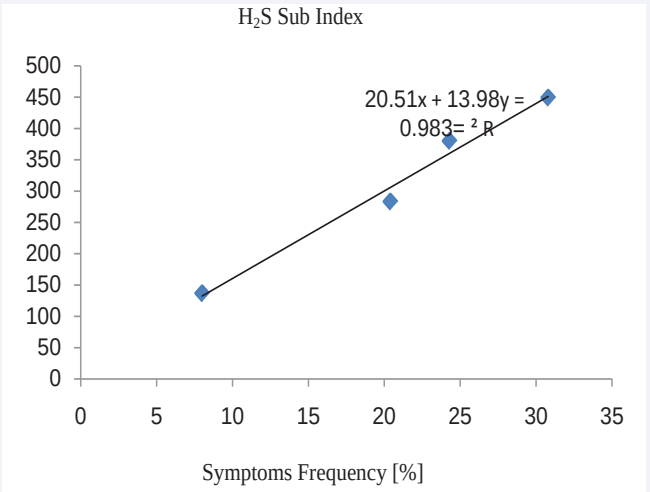

Figure 39 Correlation between H_2S sub index and dermal symptoms.

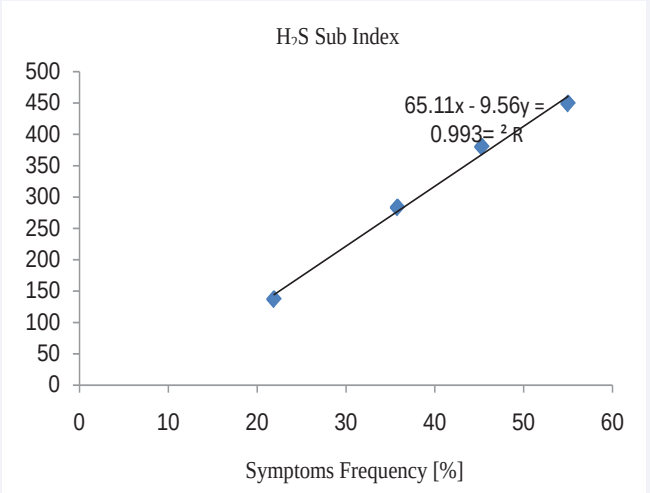

Figure 40 Correlation between H_2S sub index and airway symptoms.

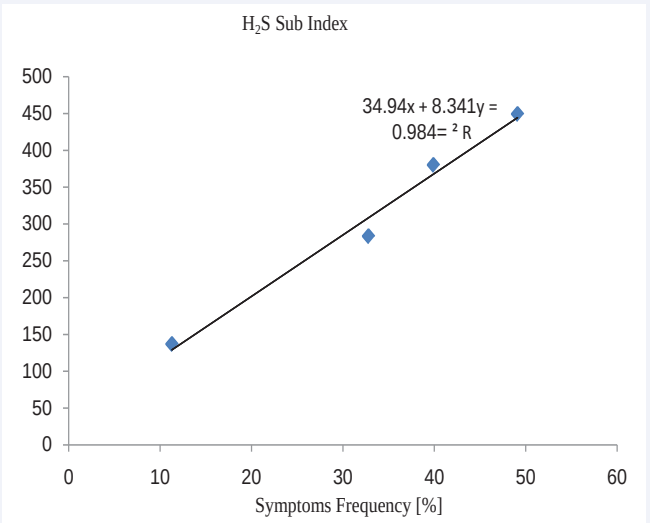

Figure 41 Correlation between H_2S sub index and eye symptoms.

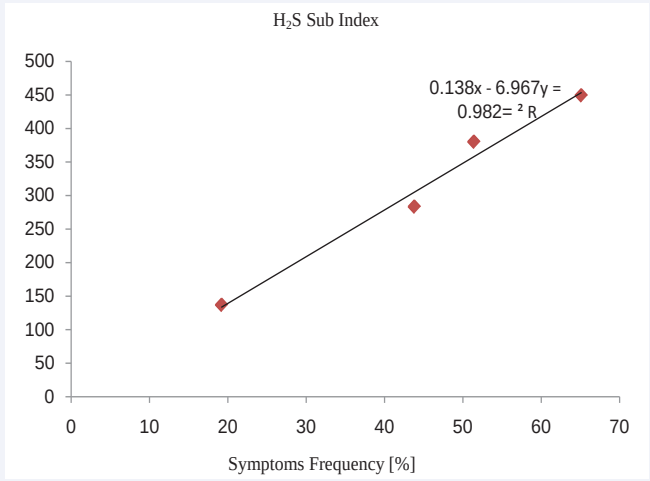

Figure 42 Correlation between H_2S sub index and eye symptoms.

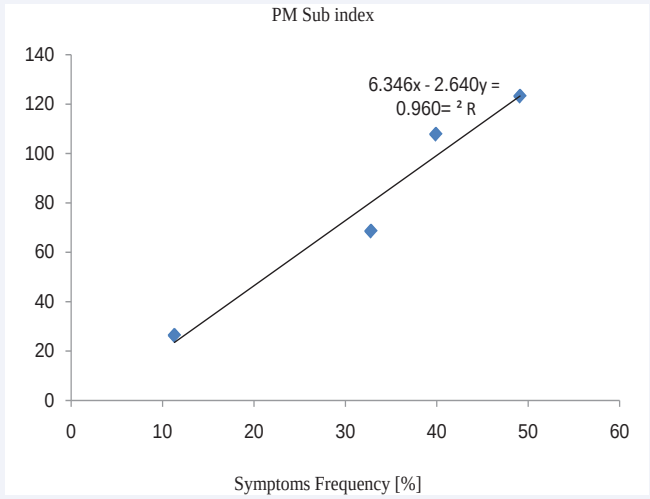

Figure 43 Correlation between MDA serum concentration and mean visual analogue scale of dermal: Airway, eye and general symptoms.

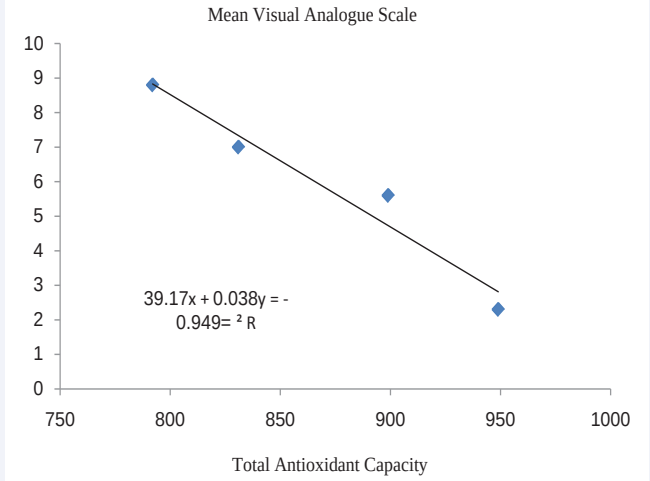

Figure 44 Correlation between total antioxidant capacity serum concentration and mean visual analogue scale of dermal: Airway, eye and general symptoms.

DISCUSSION

Our present study indicated an association between air pollution and development of dermal, respiratory, eye and general symptoms in Kirkuk community. The developments of symptoms were influenced by air pollution concentration. The impact was more prominent on respiratory symptoms, which is the common one in the polluted and control area. The findings of an Italian study suggest that emissions from chipboard industries might have a serious impact on children's respiratory health status [29]. Wilson *et al.* found the risks of respiratory symptoms in their study were increased by smoking, occupational exposures to dust and gas, and combined residence-related exposures such as living close to a main road, factory or chimney, indoor coal use and the presence of irritating smoke during cooking, among other risk factors [30].

According to Gul *et al.* results, statistically significant differences were observed among the three groups for health complaints such as chronic pulmonary disease, tightness in the chest, coughing and phlegm [31]. Morgenstern *et al.* found that adjusted odds ratios (ORs) for wheezing, cough without infection, dry cough at night, bronchial asthma, bronchitis and respiratory infections indicated positive associations with traffic-related air pollutants [32]. They also found that increased levels of NO_2 were associated with increased prevalence of respiratory health symptoms.

According to results of the study of Langkulsen *et al.*, the prevalence of respiratory symptoms and impaired lung function were higher among children living in areas with high pollution than those in areas with low pollution [33]. Epton *et al.* detected no significant effect of ambient wood-smoke particulate air pollution on lung function of healthy school-aged male students, but a small effect on cough [34]. Arroya *et al.* study indicated that the prevalence of asthma was found significantly related to traffic flow density [35].

Several studies revealed that ozone was associated with increases in hospital admissions for asthma, school absenteeism for respiratory illnesses, respiratory problems associated with asthma and decreases in respiratory functions [36-38]. The relationship between NO_2 and health effects including respiratory symptoms, episodes of respiratory illness, lung function and even mortality was shown in several studies [39,40]. Apart from the ambient air quality, air quality in and near schools is also important because students spend considerable amount of their time in the schools [41]. According to Zhao *et al.* indoor chemical air pollutants of mainly outdoor origin could be risk factors for pupils' respiratory symptoms at school [42].

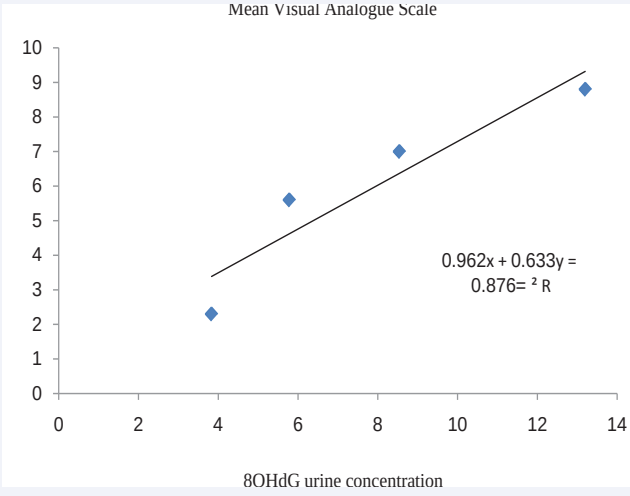

Figure 45 Correlation between 8OHdG urine concentration and mean visual Analogue scale of dermal, Airway, eye and general symptoms.

Regarding outdoor concentrations measured in different areas in Kirkuk City, NO_2, SO_2, H_2S, Ozone, CO and PM concentration was highest at the area with highest prevalence of dermal, eye, airway and general symptoms. Outdoor air quality may affect respiratory health symptoms, dermal, eye, and general symptoms those living in Kirkuk city. The health hazard increased with the increase of air pollution index. The results of this study suggest that air quality in industrially polluted sites might increase the risk of respiratory health conditions of students. We found out that the frequency of the indicators related to some measures of respiratory, skin, eye health was higher for the area with high air pollution index.

In the present study, the health impact of air pollution was evaluated using visual analogue scale [VAS] , which indicated that VAS significantly correlated to the air pollution concentration. VAS was lower in area with lower air pollution [area D] and higher in area with higher air pollution, whether the analyses performed for each system symptoms or pooled together. In addition, there was a highly significant differences in VAS between the different areas [A,B,C,D]. The higher visual analogue scale was demonstrated in area A, which was with higher air pollution index for all elements.

Using a logistic regression, air pollution in Kirkuk city was a significant risk factor for development of dermal (OR=3.97, P=0.001), airway (OR=3.05.P=0001), eye (OR=5.52, P=0.0001), and general (OR=4.97, P=0.001) symptoms. In addition, the overall odd ratio (OR=6.17, P=0.0001) for all symptoms pooled together, indicated that air pollution in Kirkuk city was a significant risk factor with a serious health impact. Numerous epidemiological studies have shown an increased morbidity and mortality due to environmental air pollution [43,44]. Environmental air does contain a complex mixture of toxics, including particulate matter (PM), irritant gases, and benzene. The chemical composition of particles does vary greatly and depends on numerous geographical, meteorological, and source-specific variables. Generally, environmental [45] particles include inorganic components (sulfates, nitrates, ammonium, chloride, and trace metals), elemental and organic carbon, biological components (bacteria, spores, and pollens), and adsorbed volatile and semivolatile organic compounds [46]. In addition, environmental particles, when mixed with atmospheric gases (ozone, sulfur nitric oxides, and carbon monoxide) can generate environmental aerosols.

The present study suggested an association between number of symptoms and levels of oxidants / antioxidant mean serum levels. Malondialdehyde mean serum levels were significantly correlated with number of symptoms, thus it was 9.81 mmol/l in individuals with ≥5 symptoms, and 3.71 in individuals without

any symptoms. The same pattern was demonstrated for 8OHdG. In contrast, total antioxidant capacity was reduced in correlation with number of symptoms. Furthermore, MDA and 8OHdG were significantly higher in polluted area as compared to non polluted areas, while TAC was significantly lower in polluted areas.

Recently, interest has focused on the ultrafine particles (UFPs) with a diameter less than 100 nm; UFPs are considered important with respect to health effects because of their very high alveolar deposition fraction, large surface area, chemical composition, and ability to enter into the circulation and induce inflammation. Vehicle emissions, in particular related to diesel engines, diesel exhaust particles (DEPs), are a major source of environmental UFPs, which in the presence of poor ventilation may penetrate indoor, where additional sources including environmental tobacco smoke, cooking, burning of candles, and chemical reactions are present [47].

The general consensus does indicate that the mechanism of air pollution-induced health effects involves an inflammation related cascade and oxidation stress both in lung, vascular, and heart tissue [48-53]. Inflammation is initially a protective mechanism which removes the injurious stimuli and produces reactive oxygen species (ROS) able to induce cell killing. In the early phase of inflammation, oxidant stress does not directly cause cell damage and can induce the transcription of stress defense genes including antioxidant genes. This preconditioning effect of ROS enhances the resistance against future inflammatory oxidant stress and promotes the initiation of tissue repair processes. The additional release of cell contents amplifies the inflammatory process and consequently can induce tissue injury [54]. Oxidation damage has been implicated in many degenerative and non degenerative diseases, including cardiovascular and pulmonary diseases, diabetes, and Alzheimer disease. Oxidation stress derived from an unbalance between ROS formation and individual antioxidant activity potentially does lead to damage of lipids, proteins, and macromolecules such as DNA and RNA [55].

Several experimental and epidemiological studies have proved exposure to air pollution to be an important determinant of overall pulmonary and cardiovascular risk damage and possibly have an influence on traditional risk factors. Although each environmental pollutant has its own mechanism of toxicity, most pollutants, like UFP, PM2.5, ozone, nitrogen oxides, and transition metals, are potent oxidants or capable of ROS production. Consequently, the promotion of oxidative stress has been identified as one of the most important mechanisms responsible for toxic air pollutant effects. Oxidative stress can trigger redox sensitive pathways that lead to different biological processes like inflammation and cell death.

Visual analog scale significantly correlated with air pollution indices, symptoms frequency, oxidant and antioxidants. In addition, air pollution indices were significantly correlated with symptoms frequency. These finding suggest the positive association between allergy/asthma development and/or exacerbation and air pollution.

In conclusion, air pollution concentration and indices were associated with frequency of respiratory, skin, eye and general symptoms. In addition, it was associated with reduction in total antioxidant capacity and increase in oxidative stress.

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