ORIGINAL ARTICLE

Indoor and Outdoor Carbon Monoxide (CO) Concentrations at Hospital Kitchens

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ABSTRACT

Carbon Monoxide (CO) poisoning is one of the most common causes of death in Iran. The present study investigated the indoor and outdoor CO concentrations at hospitals under the supervision of Mazandaran University of Medical Sciences in Sari, Iran.Indoor and outdoor measured CO were conducted over a period of one month during the 2012 winter season in 4 hospital kitchens using a direct measurement device specialized for CO. The average concentrations of CO gas through gas measuring stations were considered at three stations both in and out of the kitchens.The highest and the lowest average concentrations of outdoor CO in Fatemeh Zahra Hospital (about 2 ppm) and Zare Hospital (about 0.33 ppm) were measured respectively. Besides, the highest and the lowest average concentrations of indoor CO were detected in Imam Hospital (as 9.66 ppm) and BuAli Hospital (as7.66 ppm). The highest ratios of I/O (approximately 10 ppm) have been conducted between 8:00 and 9:00a.m. The lowest median concentrations of CO (approximately 8 ppm) between 11:00 and 12:00 a.m. have been measured. Concentrations of CO in all hospitals in this study were significant.This fact shows poorly ventilation of kitchen due to lack of ventilation design engineering.

KEYWORDS: *Carbon Monoxide (CO), Hospital, Kitchen, Iran*

INTRODUCTION

Any substance in the air, which is harmful to the environment and human health,is named as air pollutant. Air pollutionis caused by the entrance of toxic gases, increase in solid and liquid particular matters in the air in a nonstandard concentration [1-2]. Nowadays, uncontrolled population growth, urbanization, unsustainable development and the lack of proper usage of natural resources has caused a polluted

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environment for humans.

Atmospheric pollutions, climate changes and related diseases are some of the most serious problems caused by human activities in this contemporary world.

The main air pollutant resources are categorizedintotwo groups including natural air pollutants and artificial air pollutants. One of the artificial air pollutants which isbeing enhanced by human developments is carbon monoxide (CO) [3-4]. CO is a colorless, odorless, tasteless and poisonous gas produced by incomplete burning of carbon-based fuels, including gas, oil, wood and coal. It is produced from the partial oxidation of carbon-containing compounds; it forms when there is not enough oxygen to produce carbon dioxide (CO_2), such as when a stove or an internal combustion engine in an enclosed space operates [5].

High concentrations of CO can cause physiological and pathological changes, and eventually death.CO combines with hemoglobin to produce carboxyhemoglobin, which usurps the space in hemoglobin that normally carries oxygen, but is ineffective for delivering oxygen to bodily tissues. CO concentrations of more than 750 ppm may convert 50% of the body's hemoglobin to carboxyhemoglobin.

A level of 50% carboxyhemoglobin may result in seizure, coma, and fatality [6]. CO poisoning causes fatigue, chest pain, depression, hallucinations, agitation, headache, confusion, dizziness and lightheadedness, nausea, vomiting, painless, drowsiness, loss of balance, impaired vision, memory impairment, difficulty walking, problems with coordination of the nervous system, convulsions, and eventually fainting [5-6] which are often the result of inadequate ventilation of the building with a direct relationship on concentration of CO [7-9]. Unfortunately, there is not any air pollution monitoring station in the Sari City and on the other hand, a large number of vehicles have to pass through narrow streets and corridors in the city center every day. Thus, the level of traffic flow in this city is high and traffic congestion might be often happened.

According to the results of previous air pollution studies in the Sari City [10-12] and other studies [9] in similar cities, the CO concentrations in the city center of Sari are likely to be high. Some studies were conducted in Sari City to determine the drivers' exposure to respirable particles in public transportation's and to measure PM10 concentrations in different areas of the Sari city [10-12]. The aim of this study was to evaluate the CO gas concentration inside and outside the hospital kitchens in Sari, the center of Mazandaran Province, northern Iran.

MATERIALS AND METHODS

This cross-sectional study has involved the participation of all government hospitals in Sari. Indoor and outdoor airs from four kitchens in four hospitals in Sari City were analyzed in January 2012. Two hospitals were located near the busy roads in Sari City center and two hospitals were located in vicinity to highways lading to the town. For each kitchen, based on farness and nearness of air exchanging places,3 stations inside and 3 stations outside of the kitchens were identified.Stations were possibly chosen to show the mean concentrations of CO inside and outside the kitchens. Air sampling heightwas mentioned in the level of respiratory individuals'standing height (150 cm above the ground level) for each indoor and outdoor monitoring. Measurements were carriedout every 5 min during a 4-hour shift working inside and outside the kitchen.Total numbers of measurementswere estimated using the factorial design formula.Based on this formula (factorial design) 576 samples were obtained. The data compared results from both inside and outside parts of the kitchen.

Number of Samples = Number of repetitions (12) × number of hospitals (4) × time (3) × Location (2) × number of days per week (2).

The concentration of CO in the environment was measured using a single calibrated gas detector SnsvrhMonitoxplus gas detector 5306 500, manufactured by Compur Company (from Germany). The detector works based on electrochemical mechanism and it is specialized for measuring CO gas. The device measures the CO concentrations from 0 ppm to 500ppm and with +2 ppm accuracy of measurement.

To analyze data, the Kolmogorov-Smirnov test was used to determine the normal distribution data. Then, one-sample t-test was usedto determine the average concentration of indoor and outdoor CO. To compare the groups, Variance analysis test (and the Tukey-test to compare binary) was used for normal distributed data and Kruskal-Wallis test was used for non-normal distributed data.

RESULTS

Figure1 shows the indoor air concentrations of COfrom within each of the four separate hospitals. It shows that the median of indoor CO concentration in Imam Hospital was more than that in other hospitals (9.66 ppm).It means that at least 50% of the amount of indoor CO in Imam Hospital was more than9.66 ppm. Besides, the figure shows that the lowest median belonged to BuAli Hospital (7.66 ppm). At least 50% of the amount of indoor CO in BuAli Hospital was more than7.66 ppm.
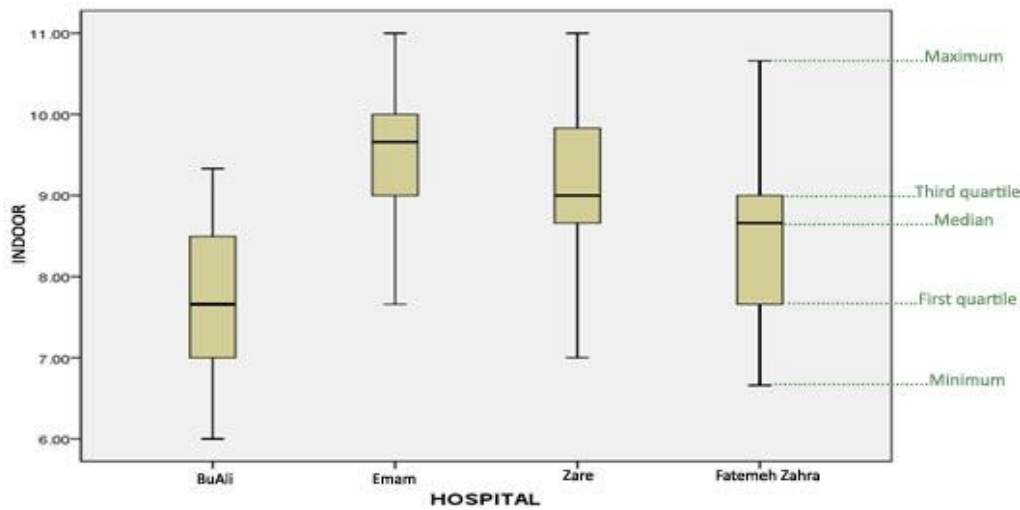
Figure2 shows the concentration of outdoor CO in each hospital as was separately done. It shows that the median amount of outdoor CO in Fatemeh Zahra Hospital was more than in other hospitals (2 ppm). At least 50% of the amount of outdoor COin Fatima Hospital was more than 2ppm. The lowest median belongs to Zare Hospital (0.33 ppm). At least 50% of the amount of outdoor CO in Zare Hospital was more than 0.33 ppm (The points out of the boxes are outliers).
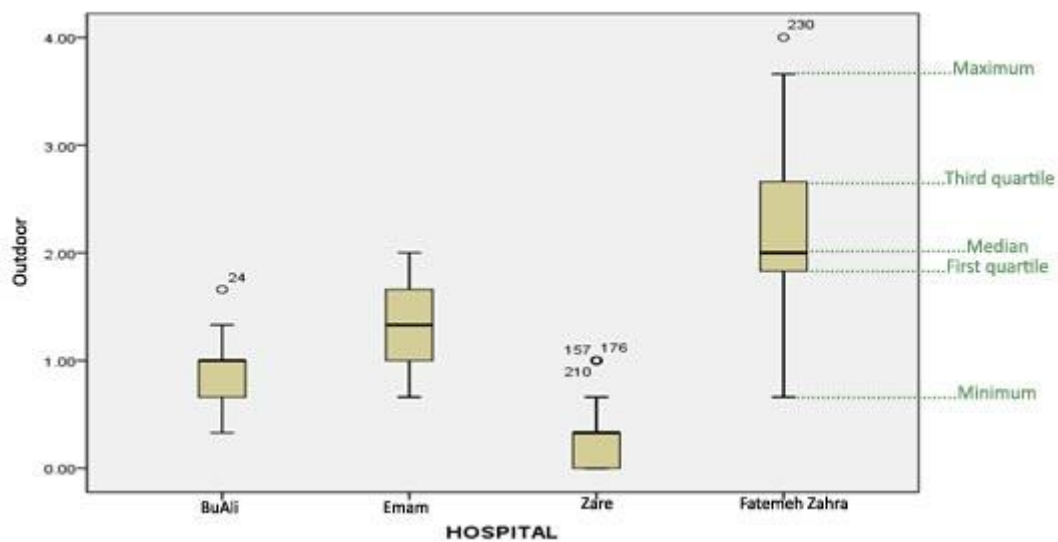

Fig 2. Outdoor CO concentration**s** in 4 sample hospitals, Sari, Mazandaran, Iran

Figure 3 shows the Input/output box plot for each hospital. It shows that I/O mean in Zare Hospital was more than that other hospitals (16.10 ppm). This means that at least 50% of the amount of I/O was more than 16.10 in Zare Hospital. Also, Fatemeh Zahra Hospital had the lowest median (about 4) among all hospitals. It means that at least 50% of the amount of I/O in Fatemeh Zahra Hospital's kitchen was more than4 (The points out of the boxes are outliers). Unfortunately, there was not any fixed monitoring site station to report of background CO concentration in Sari city.
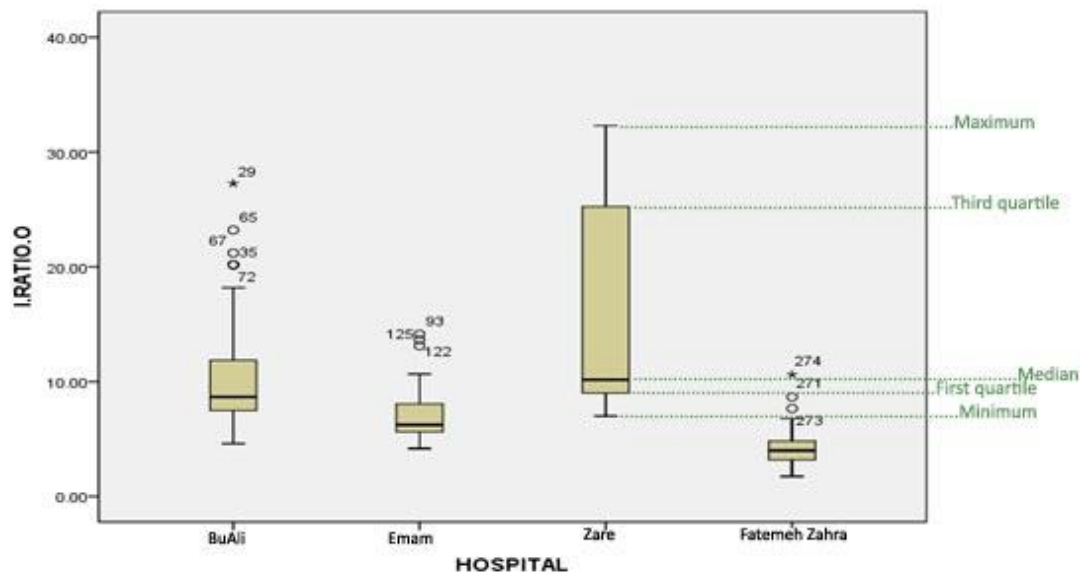
Fig 3. Indoor/outdoor in sample hospitals, Sari, Mazandaran, Iran

Figure 4 shows changes in the indoor CO concentration trend at different times of a day. The highest median concentrations of CO have been measured from 8:00 to 9:00a.m.(10 ppm) and the lowest mean concentrations of CO have been measured between the hours of 11:00 to 12:00a.m.(8 ppm).Indoor CO, outdoor CO and I/O ratio were significantly different in the four sample hospitals ($P<0.05$).

BuAli, Zare and Fatemeh Zahra Hospitals had the lowest measured amounts of indoor, outdoor and I/O CO concentrations respectively. Moreover, there was a significant difference among the indoor, outdoor and I/O ratio for CO concentrations in each hospital's different measuring times. The lowest CO concentration was measured from 11:00 to 12:00a.m.and there was a significant difference between the lowest CO concentrations in different hospitals ($P<0.05$).
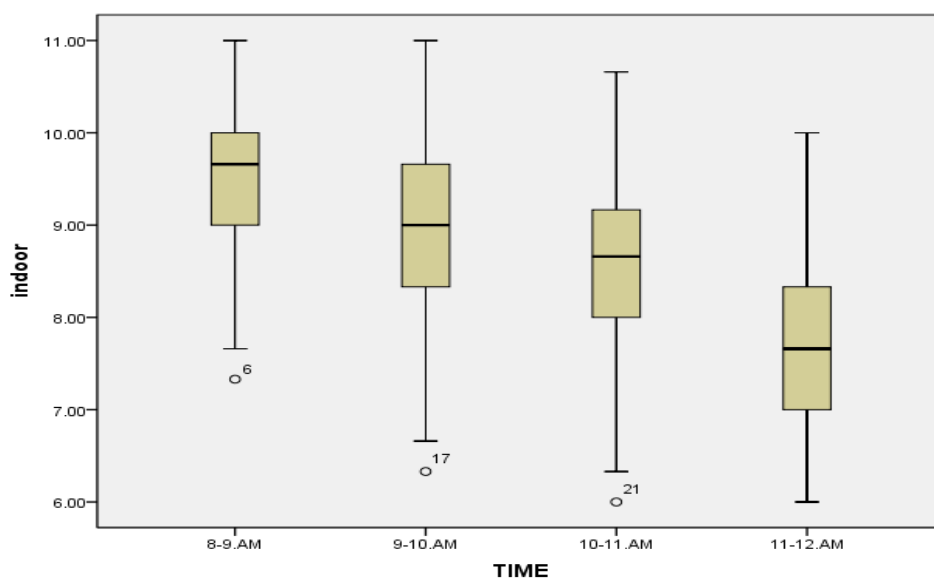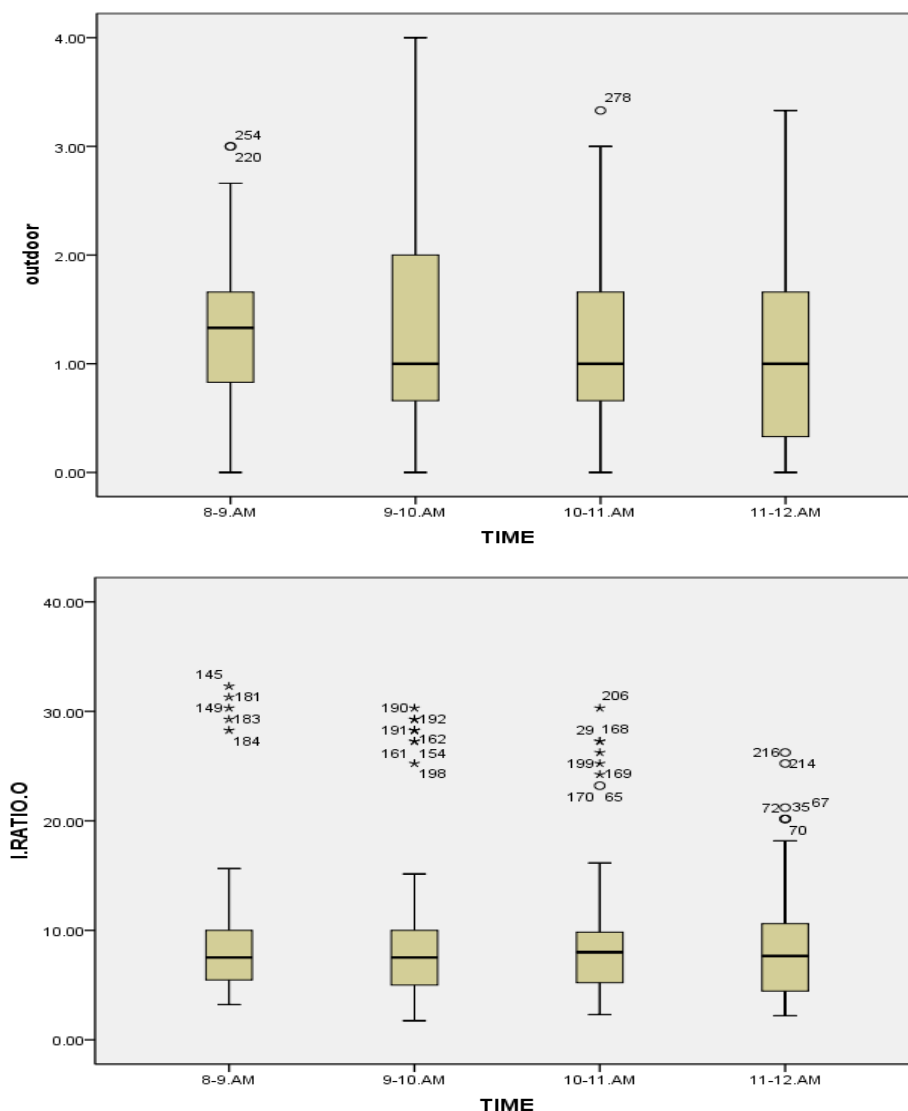
Fig. 4. Changes in trend of CO concentrations at different times of a day in different hospitals, Sari, Mazandaran, Iran

The Fisher test statistics was determined to be about 7.354 with a significant level of 0.001 ($P<0.05$). It showed a significant difference between the 1-hour measurements of CO concentrations in different hospitals. Post-hoc tests (Tukey-test) has shown a significant difference ($P<0.05$) between indoor measured CO in BuAli and Imam Hospitals, also in BuAli and Zare Hospitals. Fisher test analysis, variance analysis and Levene tests have shown significant difference among the average amounts of 1-hour measurement of outdoor COs in different hospitals. The most and the least amounts of outdoor 1hour measured CO as has been recorded in Fatemeh Zahra and Zare Hospitals were 2.19 and 0.26 respectively. Due to the Fisher statistics value of (173.858), the significant level determined was 0.0001 ($P<0.05$). There were significant differences between outdoor measured CO in hospitals two by two. The average

amount of 1hour indoor CO in Sari had no significant difference with the national standards of 9 ppm (Significant level=0.105>0.05). However, the average amount of 1 hour outdoor CO in Sari had a significant difference with national standards of 9 ppm (Significant level=0.001<0.05). A look at the figureshas revealed wide and negative confidence intervals withdistance from standard size.

DISCUSSION

The present study was conducted in the month of January 2012 to find the effect of outdoor CO concentrations on indoor CO concentrations in the hospital kitchens in Sari City. The mean CO concentrations in all hospitals were less than threshold limit value (TLV) and occupational exposure limit (OEL) recommended by American Conference of Governmental Industrial Hygienists

(ACGIH) and Iranian Committee for Review and Collection of Occupational Exposure Limit (ICRCOEL) respectively [13-14]. The average CO concentrations indoor restaurants' kitchen was lower than standards [15].

The result showed that there was no significant relationship between indoor and outdoor CO concentrations in samples of the study. Thus, we cannot estimate the inside CO concentration based on information regarding outside CO concentration. Totally, it is important to monitor and control the CO concentrations inside the hospitals mainly because of the people's presence inside the hospitals (especially in the kitchen).

The highest and lowest median amounts of outdoor CO have been recorded in Fatemeh Zahra and Zare Hospitals respectively. However, Fatemeh Zahra Hospital is located in a high traffic flow area in the city center thus it is likely to have a higher outdoor CO concentrations and lowest I/O ratio. On the other hand, Zare Hospital is located in a suburban area surrounded by woods, therefore the lowest outdoor CO concentrations and highest I/O ratio were found in this hospital.

Outdoor CO measurements have also shown that the amount of measured CO in hectic traffic was more than that in other places [16-17]. The highest median of CO concentration inside the kitchen was related to Imam Hospital. It is the biggest hospital in Sari City and therefore some factors such as long cooking time, lack of engineering designed ventilation system for cooking process, and high traffic flow on the road in proximity to this hospital may explain high indoor CO concentrations.

The ratio of I/O between 8:00 to 9:00 a.m. resulted the highest median. The high level of consumption of gas fuel for heating and boiling water to prepare rice and curries might be the main reason of high Indoor CO concentrations and a higher I/O ratio. However, the lowest median of I/O ratio has been calculated between the 11:00 to 12:00 a.m. The movement of people for jobs and schools, which emitted CO into the ambient air, may increase outdoor concentrations and end of cooking process in the kitchen may decrease indoor CO concentrations. Therefore, it resulted in the decrease of I/O ratio between the 11:00-12:00 a.m.

The gradual increase in air temperature due to unstable weather conditions and increasing pollutants in the air also caused a reduction in I/O between the hours of 11:00 to 12:00 a.m. The ratio of I/O can be very different due to the factors such as measurement, design, construction, etc. One of the factors that plays a major part in air pollutants concentration is weather changes [16, 18].

CONCLUSION

The amount of indoor and outdoor CO in sample hospitals had no significant relationship

with each other. CO concentration had significant difference in different hospitals. The significant difference between CO concentrations has caused by inadequate air condition inside the kitchens, whichwas because of the lack of ventilation.

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