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# Karbonmonoksit İntoksikasyonu ile Acil Servise Başvuran Hastaların Başvuru Zamanı ve Mevsimsel Değişikliğinin İncelenmesi

## Seasonal Changes and Time of Admission to the Emergency Unit for Patients with Carbonmonoxide Intoxication

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***ÖZ***

***GİRİŞ ve AMAÇ:*** *Karbonmonoksit (CO) intoksikasyonu mortalitesi yüksek bir hastalıktır. Non spesifik semptomlarla Acil Servis başvuruları görülebilmektedir. CO intoksikasyonu insidansı, tanı koymadaki zorluklar dolayısı ile tam olarak bilinememektedir. Biz bu çalışmada, yoğun Acil Servis başvurularında mevsimsel değişikliklerin öneminin vurgulanması ile CO intoksikasyonu bulgularının çoğu zaman genel ve tanıya yardımcı olma olasılığı düşük semptomlarının tanı koymadaki farkındalığı artırabileceğinİ, ayrıca CO intoksikasyonu tanısı alan hastaların demografik verilerinin ve 1 yıllık mortalite araştırılmasının hastalığın tanı ve tedavisi yanında acil serviste gözlem süreleri ve hospitalizasyon önerilerine katkı sunabileceğini düşündük.*

***YÖNTEM ve GEREÇLER:*** *Hastane veri sistemi retrospektif olarak incelendi ve 4 yıllık süre içerisinde (01.01.2015 - 01.12.2019 tarihleri arasında) hastanemiz Acil Tıp Kliniğine başvuran, kan gazında karboksihemoglobin (COHb) düzeyi %10'un üzerinde olan hastalar tespit edildi.*

***BULGULAR:*** *Çalışmamıza 160'ı kadın, 251'i erkek olmak üzere toplam 411 hasta dahil edildi. CO intoksikasyonu tanısı alan hasta sayısı 63 hasta ile en fazla Ocak ayında (15.33%) görüldü. Mart ayında 59 (14.36%), Aralık ayında 48 (11.68%) hasta tespit ettik. CO intoksikasyonunun en fazla 21 ile 40 yaşları arasında (186 hasta 45.26%) olduğunu tespit ettik. Bu süreçte mortal seyreden 17 hastamız (4.14%) oldu. 1 yıllık mortalitenin sonbaharda, kış ve ilkbahara göre daha fazla olduğunu tespit ettik (p=0.008). Ancak genel mortalite açısından mevsimler arasında anlamlı bir fark yoktu (p=0.685). Bulantı, kusma, karın ağrısı, baş dönmesi gibi non spesifik semptomlarla başvuran ve CO intoksikasyonu saptanan hastalar arasında mevsimsel bir faklılılığın olmadığı görüldü.*

***TARTIŞMA ve SONUÇ:*** *Karbonmonoksit intoksikasyonu görülme sıklığı özellikle kış aylarında artış göstermektedir. Yoğun Acil Servis başvurularında mevsimsel ve iklimsel değişikliklerin olduğu dönemlerde; özellikle non spesifik semptomlarla başvuran hastalar için hekimlerin farkındalığını artıracak önlemler alınmalıdır.*

***Anahtar Kelimeler:*** *Karbonmonoksit İntoksikasyonu, Mevsimsel Değişiklikler,Mortalite*

***ABSTRACT***

***INTRODUCTION:*** *Carbonmonoxide (CO) intoxication is a disease with high mortality rates. Emergency unit admissions with non-specific symptoms are observed. The incidence of CO intoxication is not clearly understood due to difficulties in diagnostic methods. In this study, we aimed to emphasize the importance of seasonal changes in emergency unit admissions and believe that symptoms of CO intoxication, which are commonly general and demostrate a low possibility to facilitate diagnosis, may increase the awareness on diagnosing, and that the demographic data and 1-year mortality evaluation of patients with CO intoxication may contribute to the duration of emergency unit stay and hospitalization recommendations of the treatment in addition to the diagnosis and treatment of the disease.*

***METHODS:*** *The data system of the hospital was retrospectively investigated and patients who had presented to the Emergency Medicine Clinics of our hospital within a 4 year period (01.01.2015 – 01.12.2019), and who had a blood carboxyhemoglobin (COHb) gas level of 10%, were determined.*

***RESULTS:*** *The study included a total of 411 patients; among these, 160 were female and 251 were male. Admission was highest in January, with 63 patients with CO intoxication (15.33%). The number of patients was 59 (14.36%) in March and 48 (11.68%) in December. CO intoxitaion was most commonly observed in the 21-40 age group (186 patients, 45.26%). We observed mortality in 17 patients (4.14%). 1-year mortality was higher in fall, compared to winter and spring (p=0.008). However, no significant difference was observed regarding seasons (p=0.685). No seasonal difference was observed in patients with non-specific symptoms such as nausea, vomiting, abdominal pain and dizziness, and diagnosed CO intoxication.*

***DISCUSSION AND CONCLUSION:*** *Incidence of carbonmonoxide intoxication increases during winter. Precautions that lead to awareness of the physicians for patients who present to emergency units, especially with non-specific symptoms at times of seasonal and climate changes.*

***Keywords:*** *Carbonmonoxide intoxication, seasonal changes, mortality*

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## INTRODUCTION

Carbonmonoxide (CO) intoxication is a common cause of emergency unit admissions and is related to high mortality rates (1). Affinity of CO for hemoglobin is much higher than that for oxygen. Thus, CO exposure nay lead to severe tissue hypoxia. Headache, nausea, vomiting, muscular pain, dizziness, altered state of consciousness and cardiac symptoms are common findings observed in patients with CO exposure-related tissue hypoxia (2). The most severe complications of CO intoxication are death and neurological sequels, and are observed due to organs with high metabolic rate such as heart and the brain (2, 3). Many studies have demonstrated a strong correlation between winter and seasonal changes and CO intoxication (4-6).

In this study, we aimed to emphasize the importance of seasonal changes in emergency unit admissions and believed that symptoms of CO intoxication that are commonly general and have low possibility to facilitate diagnosis, may increase the awareness on diagnosing, and that the demographic data and 1-year mortality evaluation of the patients with CO intoxication may contribute to the duration of emergency unit stay and hospitalization recommendations of the treatment in addition to the diagnosis and treatment of the disease.

## MATERIALS AND METHODS

This study was conducted at a third degree research and training hospital that has an average of 400.000 admission yearly, between 02.01.2020 and 14.01.2020, with the approval of the local ethical committee (no. 2019-121). The data system of the hospital were retrospectively investigated and patients who had presented to the Emergency Medicine Clinics of our hospital within a 4-year period (01.01.2015-01.12.2019) due to a blood carboxyhemoglobin level (COHb) higher than 10%, were determined. Patients with insufficient data in the data system, those younger than 18 years of age and those who had self suicidal CO exposure, were excluded.

A total of 423 patients with a COHb level higher than 10% were determined. Among these, 12 were excluded who had insufficient data in the hospital data system, and the study was completed with 411 patients. Demographic characteristics such as age, gender, season of admission, complaint on admission, COHb level and mortality were recorded into the statistical data program. March, April and May were accepted as months of spring, June, July and August were accepted as months of summer, September, October and November were accepted as months of autumn, and December, January and February were accepted as months of winter.

## RESULTS

We had 411 patients with CO poisoning (160 females and 251 males), mean age was 41.08 ± 13.79 (range 18-87). In 2015 there was 81 (19.71%) cases while 109 (26.52%) cases in 2016, 76 (18.49%) cases in 2017, 87 (21.17%) cases in 2018 and 58 (14.41%) cases in 2019. January has the highest frequency of CO poisoning with cases, March was the second with 59 (14.36%) cases and December was the third with 48 (11.68%) cases (Table 1).

We detected that CO poisoning was most common between 21 and 40 ages with 186 (45.26%) cases, 41 - 60 ages followed them with 163 (39.66%) cases (Table 2).

When we evaluated cases with regard to seasons we found that, age was higher in spring and autumn than winter (p=0.011). Male gender frequency was higher in summer and autumn than winter (p=0.025). Smoke exposure was higher in winter than other seasons, also was significantly higher in spring than summer and autumn (p<0.001). Headache frequency was higher in summer than spring and autumn (p=0.044). Chest pain frequency was higher in autumn than winter (p=0.022). Psychogenic symptoms frequency was higher in summer than winter (p=0.018). Myalgia frequency was higher in spring and autumn than winter (p=0.036). High fever frequency was high in summer than spring and winter (p=0.011).

**Table 1. Frequency of CO poisoning for each years and months**

| | Year | | | | | |
|---|---|---|---|---|---|---|
| **Month** | 2015 | 2016 | 2017 | 2018 | 2019 | Total |
| **January** | 22 (27.16%) | 18 (16.51%) | 11 (14.47%) | 4 (4.60%) | 8 (13.79%) | 63 (15.33%) |
| **February** | 5 (6.17%) | 10 (9.17%) | 7 (9.21%) | 16 (18.39%) | 2 (3.45%) | 40 (9.73%) |
| **March** | 22 (27.16%) | 13 (11.93%) | 8 (10.53%) | 10 (11.49%) | 6 (10.34%) | 59 (14.36%) |
| **April** | 4 (4.94%) | 9 (8.26%) | 7 (9.21%) | 8 (9.20%) | 2 (3.45%) | 30 (7.30%) |
| **May** | 3 (3.70%) | 8 (7.34%) | 0 (0.00%) | 5 (5.75%) | 4 (6.90%) | 20 (4.87%) |
| **June** | 0 (0.00%) | 5 (4.59%) | 2 (2.63%) | 3 (3.45%) | 8 (13.79%) | 18 (4.38%) |
| **July** | 4 (4.94%) | 7 (6.42%) | 2 (2.63%) | 6 (6.90%) | 5 (8.62%) | 24 (5.84%) |
| **August** | 4 (4.94%) | 4 (3.67%) | 7 (9.21%) | 2 (2.30%) | 7 (12.07%) | 24 (5.84%) |
| **September** | 3 (3.70%) | 5 (4.59%) | 4 (5.26%) | 6 (6.90%) | 7 (12.07%) | 25 (6.08%) |
| **October** | 2 (2.47%) | 6 (5.50%) | 11 (14.47%) | 8 (9.20%) | 8 (13.79%) | 35 (8.52%) |
| **November** | 3 (3.70%) | 5 (4.59%) | 7 (9.21%) | 9 (10.34%) | 1 (1.72%) | 25 (6.08%) |
| **December** | 9 (11.11%) | 19 (17.43%) | 10 (13.16%) | 10 (11.49%) | 0 (0.00%) | 48 (11.68%) |
| **Total** | 81 (100.0%) | 109 (100.0%) | 76 (100.0%) | 87 (100.0%) | 58 (100.0%) | 411 (100.0%) |
| **Data were given as frequency (percentage)** | | | | | | |

**Table 2. Frequency of CO poisoning with regard to age groups for each year**

| | Year | | | | | |
|---|---|---|---|---|---|---|
| **Age Groups** | 2015 | 2016 | 2017 | 2018 | 2019 | Total |
| **≤20** | 1 (1.23%) | 9 (8.26%) | 3 (3.95%) | 11 (12.64%) | 3 (5.17%) | 27 (6.57%) |
| **21-40** | **55 (67.9%)** | **44 (40.37%)** | **26 (34.21%)** | **36 (41.38%)** | **25 (43.10%)** | **186 (45.26%)** |
| **41-60** | 22 (27.16%) | 45 (41.28%) | 37 (48.68%) | 35 (40.23%) | 24 (41.38%) | 163 (39.66%) |
| **61-80** | 3 (3.70%) | 10 (9.17%) | 8 (10.53%) | 4 (4.60%) | 5 (8.62%) | 30 (7.30%) |
| **>80** | 0 (0.00%) | 1 (0.92%) | 2 (2.63%) | 1 (1.15%) | 1 (1.72%) | 5 (1.22%) |
| **Total** | 81 (100.0%) | 109 (100.0%) | 76 (100.0%) | 87 (100.0%) | 58 (100.0%) | 411 (100.0%) |
| **Data were given as frequency (percentage)** | | | | | | |

Allergy frequency was higher in summer and autumn than winter and spring (p=0.030). Upper respiratory tract infection symptoms frequency was higher in autumn than spring and winter, also was significantly higher in summer than spring (p=0.003). Trauma frequency was higher in winter than spring and summer (p=0.043). There were no significant differences between seasons with regard to nausea/vomiting, abdominal pain, dizziness, dyspnoea, syncope, alcohol usage, visual impairment and crisis. None of our cases was non-symptomatic.

We had 17 (4.14%) mortal cases within this period. Below 1-year mortality rate was significantly higher in autumn than winter and spring (p=0.008). On the other hand, there was no significant difference between seasons with regard to overall mortality (p=0.685). Haemoglobin values was significantly higher in autumn than winter (p<0.001). CO Hb values was significantly higher in winter than other seasons, additionally was significantly higher in spring than summer (p<0.001). There were no significant differences between seasons with regard to pH, CO2, bas excess, and lactate values (Table 3).

**Table 3. Summary of patients' characteristics with regard to seasons**

| | Season | | | | | |
|---|---|---|---|---|---|---|
| | Winter | Spring | Summer | Autumn | Total | p |
| **n** | 151 | 111 | 64 | 85 | 411 | N.A |
| **Age** | 38.23 ± 15.21 [a] | 43.05 ± 12.85 [b] | 41.30 ± 12.55 [ab] | 43.40 ± 12.45 [b] | 41.08 ± 13.79 | 0.011 |
| **Male Gender** | 79 (52.32%) [a] | 69 (62.16%) [ab] | 46 (71.88%) [b] | 57 (67.06%) [b] | 251 (61.07%) | 0.025 |
| | | | | | | |
| **Nausea/Vomiting** | 52 (34.44%) | 35 (31.53%) | 16 (25.00%) | 18 (21.18%) | 121 (29.44%) | 0.142 |
| **Abdominal Pain** | 2 (1.32%) | 5 (4.50%) | 3 (4.69%) | 3 (3.53%) | 13 (3.16%) | 0.417 |
| **Dizziness** | 5 (3.31%) | 7 (6.31%) | 0 (0.00%) | 5 (5.88%) | 17 (4.14%) | 0.172 |
| **Smoke Exposure** | 48 (31.79%) [a] | 22 (19.82%) [b] | 1 (1.56%) [c] | 7 (8.24%) [c] | 78 (18.98%) | **<0.001** |
| **Headache** | 12 (7.95%) [ab] | 3 (2.70%) [a] | 7 (10.94%) [b] | 2 (2.35%) [a] | 24 (5.84%) | 0.044 |
| **Chest Pain** | 10 (6.62%) [a] | 13 (11.71%) [ab] | 9 (14.06%) [ab] | 17 (20.00%) [b] | 49 (11.92%) | 0.022 |
| **Psychogenic Symptoms** | 4 (2.65%) [a] | 8 (7.21%) [ab] | 9 (14.06%) [b] | 5 (5.88%) [ab] | 26 (6.33%) | 0.018 |
| **Dyspnoea** | 19 (12.58%) | 18 (16.22%) | 9 (14.06%) | 15 (17.65%) | 61 (14.84%) | 0.721 |
| **Syncope** | 9 (5.96%) | 10 (9.01%) | 3 (4.69%) | 3 (3.53%) | 25 (6.08%) | 0.414 |
| **Myalgia** | 0 (0.00%) [a] | 6 (5.41%) [b] | 1 (1.56%) [ab] | 3 (3.53%) [b] | 10 (2.43%) | 0.036 |
| **High Fever** | 0 (0.00%) [a] | 1 (0.90%) [a] | 4 (6.25%) [b] | 2 (2.35%) [ab] | 7 (1.70%) | 0.011 |
| **Alcohol Usage** | 0 (0.00%) | 2 (1.80%) | 1 (1.56%) | 1 (1.18%) | 4 (0.97%) | 0.468 |
| **Allergy** | 0 (0.00%) [a] | 0 (0.00%) [a] | 2 (3.13%) [b] | 3 (3.53%) [b] | 5 (1.22%) | 0.030 |
| **URTI Symptoms** | 4 (2.65%) [ab] | 0 (0.00%) [b] | 5 (7.81%) [ac] | 8 (9.41%) [c] | 17 (4.14%) | **0.003** |
| **Visual Impairment** | 0 (0.00%) | 0 (0.00%) | 1 (1.56%) | 0 (0.00%) | 1 (0.24%) | 0.143 |
| **Seizures** | 1 (0.66%) | 0 (0.00%) | 1 (1.56%) | 3 (3.53%) | 5 (1.22%) | 0.133 |
| | | | | | | |
| **Trauma** | 7 (4.64%) [a] | 0 (0.00%) [b] | 0 (0.00%) [b] | 2 (2.35%) [ab] | 9 (2.19%) | 0.043 |
| | | | | | | |
| **Mortality** | | | | | | |
| **<6 months** | 0 (0.00%) | 1 (0.90%) | 1 (1.56%) | 3 (3.53%) | 5 (1.22%) | 0.122 |
| **<1 year** | 0 (0.00%) [a] | 1 (0.90%) [a] | 1 (1.56%) [ab] | 5 (5.88%) [b] | 7 (1.70%) | 0.008 |
| **Total** | 7 (4.64%) | 3 (2.70%) | 2 (3.13%) | 5 (5.88%) | 17 (4.14%) | 0.685 |
| **pH** | 7.379 (7.354 - 7.409) | 7.379 (7.345 - 7.409) | 7.39 (7.366 - 7.422) | 7.382 (7.356 - 7.411) | 7.382 (7.354 - 7.411) | 0.339 |
| **$CO_2$** | 42.50 (37.30 - 46.80) | 44.10 (39.00 - 50.60) | 44.00 (39.35 - 49.85) | 44.90 (39.80 - 50.40) | 43.10 (38.50 - 49.20) | 0.107 |
| **Bas Excess** | 1.80 (0.80 - 3.30) | 1.30 (0.60 - 2.50) | 2.25 (1.00 - 4.05) | 1.90 (0.90 - 3.20) | 1.70 (0.80 - 3.30) | 0.072 |
| **Lactate** | 1.90 (1.48 - 2.61) | 1.80 (1.40 - 2.43) | 1.92 (1.64 - 2.62) | 1.95 (1.47 - 2.40) | 1.90 (1.48 - 2.52) | 0.429 |
| **Haemoglobin** | 14.45 ± 2.09 [a] | 14.89 ± 2.31 [ab] | 15.21 ± 1.95 [ab] | 15.66 ± 2.16 [b] | 14.94 ± 2.18 | **<0.001** |
| **CO Hb** | 15.00 (11.70 - 22.50) [a] | 12.30 (11.00 - 19.90) [b] | 11.45 (10.60 - 13.15) [c] | 11.60 (10.50 - 14.00) [bc] | 12.60 (10.90 - 18.80) | **<0.001** |

*Data were given as mean ± standard deviation or median (IQR) for continuous variables according to normality and frequency (percentage) for categorical variables*

*URTI: Upper Respiratory Tract Infection*

*Same letters denote lack of significant difference between groups*

Statistical Analysis

All analysis were performed on SPSS v21 (SPSS Inc., Chicago, IL, USA). Kolmogorov-Smirnov test was used for determining whether variables are normally distributed. Data were given as mean ± standard deviation or median (IQR) for continuous variables according to normality and frequency (percentage) for categorical variables. Normally

distributed variables (age and haemoglobin) were analysed with one-way analysis of variances (ANOVA). Pairwise comparison of these variables were performed by using the Tukey test. Non-normally distributed variables (pH, CO2, bas excess, lactate, Co Hb) were analysed with the Kruskal Wallis test. Pairwise comparison of these variables were performed with the Bonferroni correction method. Categorical variables were evaluated with the Chi-square test. $P<0.05$ values were accepted as statistically significant results.

## DISCUSSION

Incidence of CO intoxication could not be clearly defined due to the difficulties in diagnosing the situation. In our study, the data of 4 years were evaluated and the incidence was observed to be 0,021%. This rate is compatible with other studies such as the study of Yurtseven et al (7). However, due to non-specific symptoms, the actual rate is expected to be higher since the number of patients with no consideration of CO intoxication or evaluation of COHb level is quite high.

We determined an important difference among patients with Co intoxication between genders in our study. Among the 411 patients included in the study, 160 were female and 251 were male. The region of the hospital is an important center of non-agricultural industry. The non-agricultural workers of the region are mostly men. The difference between genders may be due to sociocultural factors; however, scientific evidence such as detailed occupational demographical data is needed. In a study investigating the risk factors for mortality in Taiwan, CO intoxication related mortality was observed to be at its peak level in cold seasons and reach a 2.15-fold increase at temperatures lower than 18.4° C daily (8). In our study, mortality was observed in 17 (4.14%) cases. Although the 1-year mortality was significantly higher in autumn compared to winter and spring, no significant difference was observed between seasons. In contrast to the literature, no statistical difference was observed with regard to general mortality. The morbidity and mortality rates reported weekly by the Disease Control and Prevention Centers (CDC) in USA demonstrates that non-self suicidal CO intoxication cases which are not related to a fire and do not result in death, are most commonly observed in December and January, and least commonly observed in July and August (9, 10). The data obtained in our study supported these findings, which revealed the highest number of diagnosed CO intoxication in January (number of cases: 63, 15.33%). In a study investigating the relation of seasonal changes and CO intoxication on 3331 patients in Pekin, the number of cases was observed to be higher in winter and meteorological changes were observed to affect the situation (11). A Taiwanese study investigating the data of patients with CO intoxication between 1999-2012, provides important information on the demographic characteristics of the national population, since it comprises a long period of time and a large sample size. In this study, most of the patients were observed to be over 50 years of age where the mean age was 36 years (12). The age range in our study was 21-40 years as well. The data we obtained support the findings in that study. In the comprehensive study of Metin et al. conducted in Türkiye in 2010, the cases of CO intoxication were most commonly observed in February, January, December and March, respectively. Seasonal evaluation revealed that intoxication cases were most common in winter months (13). However, the data source used in the study of Metin et al., did not include demographic data such as age and gender. Thus, we believe that nation-wide studies should be conducted that would include demographic data as well. Although the findings observed were similar to those observed in our study, it is noted that the cases observed within months of spring, autumn and summer are not few. We believe that cases of intoxication are observed due to meteorological reasons in spring and to liquid based water heaters used in small baths, which are not properly ventilated in the summer.

CO intoxication may manifest mild findings or symptoms, or it may lead to severe morbidities. Depending on the duration of exposure, vital organ damage or even death may be observed. Patients with CO intoxication generally present to emergency units with dizziness, fatigue, headache, nause and vomiting in cases of mild intoxication (14). In our study, significant seasonal variations

were observed among patients presenting to emergency units with non-specific symptoms such as nausea, vomiting, abdominal pain, respiratory distress and syncope, who were diagnosed to have CO intoxication. Furthermore, in the case where a high COHb level was detected in one member of the family, individuals who had been in the same environment and for whom treatment was begun considering CO intoxication due to their symptoms but observed to have normal COHb level, were excluded. Considering the patients with normal COHb level due to delayed admission as well, it is important to consider a higher incidence of exposure. The data obtained in our study and other studies that demonstrate an increase during winter and the difficulties in diagnosing CO intoxication, non-invasive methods may be useful for patients with non-specific symptoms, especially in emergency units with dense patients admission. The COHb level may be measured non-invasively using a pulse oximeter (15). The sensitivity and specificity of non-invasive measurement of COHb level have been reported as 94% and 54%, respectively. In that study, the measurements of pulseoxymeter and blood COHb analysis were compared in 10.856 patients (16). COHb measurement using the pulseoxymeter may be added to routine triage applications that monitor the parameters such as pulse, blood pressure, body temperature and oxygen saturation, particularly in cold weather conditions. An early diagnosis would contribute to decreased hospitalization and mortality.

Our study is important in demonstrating the importance of diagnosis of CO intoxication due to the extent of non-specific symptoms involved in the situation.

## LIMITATIONS

Our study had some limitations. First of all, it was a single center study, and the findings observed cannot be generalized. The diagnosis of CO intoxication is generally possible with the foresight of the physician and a good anamnesis. Thus, patients with non-specific symptoms may not be diagnosed properly, making the access of all patients accurately impossible. In our study, non-invasive COHb measurement had been carried out in a certain time interval when patient files were examined, and the related data could not be used due to improperness of the data. This may be the cause of the lower incidence detected compared to the actual incidence. Non-detected and non-evaluated neuropsychiatric sequelae in patients are another limitation of our study. Furthermore, the information whether hyperbaric oxygen treatment was performed or not was also missing, as the final limitation.

## REFERENCES

1) Braubach M, Algoet A, Beaton M, Lauriou S, Héroux ME, Krzyzanowski M. Mortality associated with exposure to carbon monoxide in WHO European Member States. Indoor Air. 2013 Apr;23(2):115-25. doi: 10.1111/ina.12007.

2) Ernst A, Zibrak JD. Carbon monoxide poisoning. N Engl J Med. 1998 Nov26;339(22):1603-8.doi: 10.1056/NEJM199811263392206

3) Zou JF, Guo Q, Shao H, Li B, Du Y, Liu M et al. A positive Babinski reflex predicts delayed neuropsychiatric sequelae in Chinese patients with carbon monoxide poisoning. Biomed Res Int. 2014;2014:814736. doi: 10.1155/2014/814736.

4) Daley WR, Smith A, Paz-Argandona E, Malilay J, McGeehin M. An outbreak of carbon monoxide poisoning after a major ice storm in Maine. J Emerg Med. 2000 Jan;18(1):87-93. doi: 10.1016/s0736-4679(99)00184-5

5) Wrenn K, Conners GP. Carbon monoxide poisoning during ice storms: a tale of two cities. J Emerg Med. 1997 Jul-Aug;15(4):465-7. doi: 10.1016/s0736-4679(97)00074-7.

6) Du T, Zhang Y, Wu JS, Wang H, Ji X, Xu T et al. Domicile-related carbon monoxide poisoning in cold months and its relation with climatic factors. Am J Emerg Med. 2010 Oct;28(8):928-32. doi: 10.1016/j.ajem.2009.06.019.

7)Yurtseven S, Arslan A, Eryigit U, Gunaydin M, Tatli O, Ozsahin F et al. Analysis of patients presenting to the emergency department with carbon monoxide intoxication. Turk J Emerg Med. 2016 Mar 8;15(4):159-62. doi: 10.1016/j.tjem.2015.05.001.

8) Shie HG, Li CY. Population-based case-control study of risk factors forunintentional mortality from carbon monoxide poisoning in Taiwan.Inhal

Toxicol 2007; Aug;19(10):905-12. doi: 10.1080/08958370701432173

9) Centers for Disease Control and Prevention (CDC). Carbon monoxide–related deaths—United States, 1999-2004. MMWR MorbMortal Wkly Rep 2007;56(50):1309-12.

10) Centers for Disease Control and Prevention (CDC). Nonfatal,unintentional, non–fire-related carbon monoxide exposures—UnitedStates, 2004-2006. MMWR Morb Mortal Wkly Rep 2008;57(33):896-9.

11) Tiekuan Du MD, Yanping Zhang MD, Jack S. Wu MD, Houli Wang MD,Xu Ji PhD et al. Domicile-related carbon monoxide poisoning in cold months and its relation with climatic factors. American Journal of Emergency Med 2010; 28, 928–932. doi: 10.1016/j.ajem.2009.06.019

12) Chien-Cheng Huang, Chung-Han Ho,Yi-Chen Chen,Hung-Jung Lin, Chien-Chin Hsu,Jhi-Joung Wang et al. Demographic and clinical characteristics of carbon monoxide poisoning: nationwide data between 1999 and 2012 in Taiwan. Scand J Trauma Resusc Emerg Med 2017; 25: 70. doi: 10.1186/s13049-017-0416-7

13) Metin S, Yıldız S,, Çakmak T, Demirbaş Ş. (2011) Frequency of carbon monoxide poisoning in Turkey in 2010. TAF Preventive Medicine Bulletin 10(5): 587–592. doi: 10.5455/pmb.20110417125648

14) Nilson D, Partridge R, Suner S, Jay G. Non-invasive carboxyhemoglobinmonitoring: screening emergency medical services patients for carbon monoxide exposure. Prehosp Disaster Med. 2010 May-Jun;25(3):253-6.doi: 10.1017/s1049023x00008128

15) Hampson NB, Scott KL. Use of a noninvasive pulse CO-oximeter to measure blood carboxyhemoglobin levels in bingo players. Respir Care. 2006 Jul;51(7):758-60.

16) Suner S, Partridge R, Sucov A, Valente J, Chee K, Hughes A et al.Non-invasive pulse CO-oximetry screening in the emergency department identifies occult carbon monoxide toxicity. J Emerg Med. 2008May;34(4):441-50. doi:10.1016/j.jemermed.2007.12.004.