

An Epidemiological Study of Carbon Monoxide Poisoning Rate and a Comparison with Other Poisonings Recorded in Mazandaran Department of Forensic Medicine, 2009-2011

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ABSTRACT

Background: Carbon monoxide is an odorless, colorless and poisonous gas. Since there is currently no information on the prevalence of carbon monoxide poisoning in Mazandaran, this study aimed to investigate the prevalence of carbon monoxide poisoning and compare its prevalence with other poisonings recorded in Mazandaran Department of Forensic Medicine, from 2009 to 2011.

Methods: This is a descriptive-analytical study, in which the information was received from Mazandaran Department of Forensic Medicine.

Results: Among the 2446 human deaths in 2009, 2010, 2011, 237 deaths were due to poisoning and 27 (11.4%) were due to carbon monoxide poisoning, which ranked third after narcotic and Aluminum phosphide intoxication. Poisoning in males was 1.7 times more than females. CO was the most common cause of deaths among people aged 21 to 30 years.

Conclusion: Considering the fact that in most cases of poisoning deaths caused by CO (silent killer) come by quietly and in a hidden manner, CO actually makes any defense and escape impossible for the person and despite seeing the shadow of death, that person will inevitably surrender and will be defeated. Therefore, it is necessary to educate and inform the public through media and educational institutions about the risks and sources of CO poisoning.

Key words: Carbon Monoxide, Forensic Medicine, Poisoning.

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INTRODUCTION

Carbon monoxide (CO) is a colorless, odorless and poisonous gas that is produced by incomplete combustion. Motor vehicles, heaters, devices that burn carbon-based fuels, and house fires are the main sources of the poisoning [1, 2]. Carbon monoxide poisoning is the major cause of deaths due to poisoning in the United States of America [1, 3, 4]. CO poisoning is the most common cause of death in inhalation injuries caused by combustible materials [5, 6]. Carbon monoxide poisoning was first described in 1865 by Claude Bernard, unintentionally or deliberately; however, intentional poisonings are 10 times more than the number of unintentional poisonings. Unintentional poisoning outbreaks dropped due to the application of early warning systems for transportation and heating

equipments. Carbon monoxide can lead to hypoxia through the formation of carboxyhemoglobin and the shift of oxyhemoglobin saturation curve to the left. CO gas is quickly absorbed by inhalation through the respiratory tract and becomes linked to hemoglobin (Hb); and carboxyhemoglobin (HbCO) is created. CO gas affinity for hemoglobin is 200-250 times greater than oxygen affinity for hemoglobin [7,8]. As a result, even with small amounts of inhaled CO, carboxyhemoglobin is formed. CO decreases carrying capacity of oxygen by red blood cells through binding to hemoglobin. Hence, the major effects of CO poisoning is caused by the decline of oxygen in the various tissues of the body. The earliest sign of poisoning is a slight headache with a feeling of heaviness in the head.

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With an increase in HbCO concentration, the intensity of headache increases, and nausea, vomiting, weakness, skin redness especially in facial area, sometimes heart palpitations, irregular heartbeats, MI, syncope, shortness of breath and difficulty in breathing ensue [9, 10]. If the blood level of HbCO exceeds 40 percent, coma occurs, and concentrations higher than 60-70% can lead to death. Unintentional poisoning with CO gas in cold seasons in our country is frequently seen due to the application of braziers or oil and gas heaters without ventilation. Criminal or suicide CO poisoning are less common in our country; although the fourth leading cause of suicide in other countries (after gunshot, hanging and drugs) is inhaling gases [3, 11]. Due to massive population growth and the use of vehicles and other sources of fossil fuels in Iran we face significant figures of human deaths caused by carbon monoxide and CO poisoning has become a common cause of death. Theoretical study of Jalili in the north west of Iran (East Azerbaijan) during a 5-year study, from 2003 to 2008 showed that 346 people died due to carbon monoxide poisoning and its rate relative to other poisonings was 11.6% [12]. Diyanat showed in a survey that the rate of CO poisoning in Tabriz from 2007 to 2009 compared to other poisonings was 17.6% and 90 people died due to CO poisoning [13]. Khademi et al. in a study of deaths caused by carbon monoxide gas in 23 provinces of the country in winter 2003 showed that 156 died of gas poisoning. Since there is currently no information on the prevalence of carbon monoxide poisoning in Mazandaran and what is certain is that ignorance and lack of information are the main cause of poisoning and mortality due to CO gas, the present study aimed to investigate causes of CO poisoning and prevalence of CO poisoning and to compare that with other poisonings within 3 years in Mazandaran Province.

MATERIALS AND METHODS

This was a descriptive-analytical study in which the necessary information was collected

from Mazandaran Department of Forensic Medicine. In order to analyze fatal poisonings in Mazandaran Department of Forensic Medicine, after autopsy and investigating the outward signs and autopsy findings, samples of entrails such as: stomach, liver, kidney, blood and urine were examined for detecting drugs, pesticides, volatile toxins such as ethanol and methanol, gas toxins such as carbon monoxide, other toxins and chemicals. In this study, all cases of poisoning constitute our study population. The contents are extracted from the pre-designed questionnaires, investigation on death scenes, and hospital records, based on ethical consents in the file of patients.

In toxicology laboratories in order to distinguish the gas poisoning, the carboxyhemoglobin of the corpse is identified using various techniques such as spectrophotometry, gas chromatography and electro-chemical methods. In our study of biological tissue samples in 2,446 corpses from Mazandaran Province during 3 years, different toxins were identified using conventional methods for poisoning analysis. CoHb in the blood of 27 cases was tested with spectrophotometer in the wavelength range of 400-600 nm and the presence of carboxyhemoglobin in different concentrations was assured. Information about age, sex, occupation, cause of poisoning and other required information were collected from the necropsy reports and case studies about the deceased within 3 years in accordance with pre-designed questionnaires. SPSS statistical software and χ^2 statistical tests were used for the analysis of relationships between variables.[7].

RESULTS

According to Table 1 deceased subjects in 2009, 2010 and 2011 were a total of 6244 people, of which 237 people were referred to Mazandaran Department of Forensic Medicine. Causes of poisoning based on the frequency were as follows:

Table 1 .Percentage of deaths caused by poisoning in Mazandaran Province in three years, 2009-2011.

	Narcotic Intoxication	Aluminium Phosphide	Co2	Agricultural Toxins	Drug Toxicity	Alcohol	Methane	Raticide	Smoke
2009	22.5%	21.4%	14%	9%	11.5%	3%	0	3%	1.4%
2010	53.6%	33.3%	14%	0	0	0	0	0	0
2011	23.9%	45.2%	12%	4.5%	2%	0	1.8%	3%	0

As can be seen, the first common cause of poisoning in Mazandaran is narcotic intoxication, the second is aluminium phosphide, and the third is Carbon monoxide. Among the total 237 cases of poisonings during these three years, 27 cases were related to carbon monoxide and in 2009, 10 cases (14%), in 2010, 10 cases (14%), and in 2011, 7 cases (12%) died due to gas poisoning. (Table 1).

Table 2. Rate of carbon monoxide poisoning in Mazandaran Province in comparison with other toxicities.

Year	Rate of Poisoning
2009	14%
2010	14%
2011	12%
In all three year	11.4%

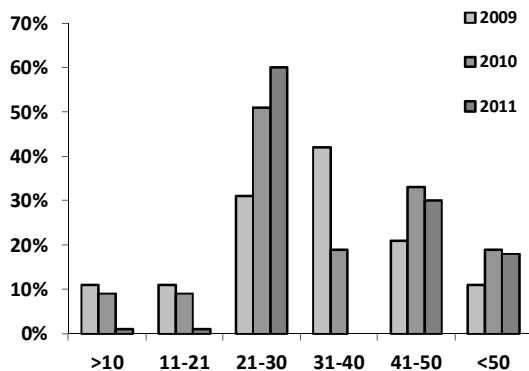


Chart 1. Frequency of deaths from carbon monoxide in Mazandaran Province by age.

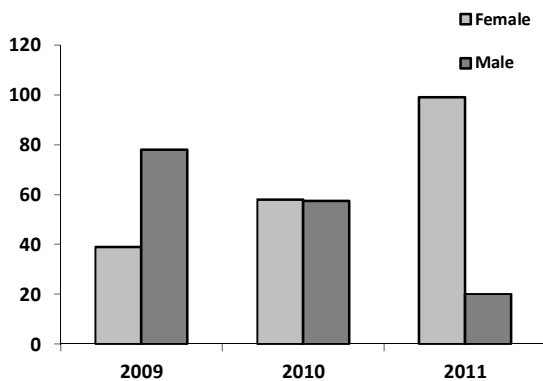


Chart 2. Frequency of deaths from carbon monoxide in Mazandaran Province by Sex.

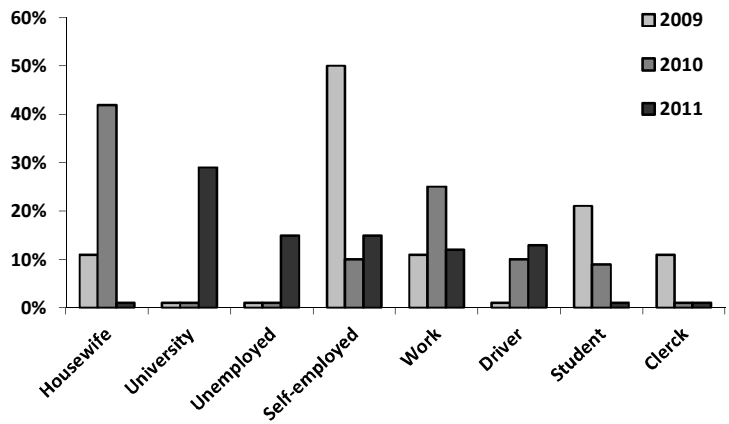


Chart 3. Frequency of death from carbon monoxide in Mazandaran Province by occupation.

In these 3 years, 26 cases (96.3%) were Iranian and 1 case (3.7%) was Afghan. The frequency of mortality in the young age group (21 to 30 years) was more than the others (chart 1). Poisoning in males was more frequent than females (1.7 Times), but the difference between them was not statistically significant (Chart 2). ($p = 0.0001$) Men were 62.9% and females 37.03%. In this study, the most observed occupation among males was self-employed and among females was housewife (Chart 3). The most common causes of poisoning were heaters, and gas boilers account for a small percentage. In this study, the picnic gas stove was the cause for 10% of poisoning which was negligible. Evaluation of the results showed a significant relationship between the location of poisoning and gender. As death place of all women was at home or bathroom, the death of 41.17% of men had occurred at home and 29.5% outside the house. In most cases deaths from carbon monoxide poisoning had occurred in the cold months of the year. Among the 20 incidents caused by CO gas poisoning, 5 (25%) occurred in the warm months and 15 (75%) in the cold ones. Twelve cases (60%) happened at night and 8 (40%) during the day. Difference in the frequency of incident was considered statistically significant in the night and day ($P < 0.0001$). The most common source of CO in all months of the year was heater. Married people's mortality was more than single ones. Most cases occurred in cities (75%) and others (25%) in the villages. Five of the incidents occurred at home;

one in a 4-person family and two cases in 2-person families. Two incidents occurred in bathroom, one of which was in a 3-person family. One incident occurred in a public bath, which was followed by a number of poisonings, but only one person died. Four incidents occurred at home due to the false application or imprudence resulting from the use of or defect in the heater installation and one incident occurred due to gas poisoning with a kerosene heater.

Poisoning prevalence was as follows: 35% at homes, 10% in bathrooms, 10% in automobiles, 5% in public bathrooms, 5% in hotels, and 5% in tents. Within 27 deaths following CO gas poisoning in 20 incidents, 16 (80%) occurred when people were alone, and 4 (20%) occurred in groups. Carbon monoxide gas poisoning causes are shown in Table 4. The corpse color in 94% of cases was rose color, light orchid color and pink. In 2% of cases the color was dark purple and one corpse was pale.

Table 3. Epidemiological features of patients with carbon monoxide poisoning.

		2009	2010	2011
Sex	Female	30%	50%	86%
	Male	70%	50%	14%
Age	10<	10%	8 %	-
	11-20	10%	8 %	-
	21-30	30%	50 %	58%
	31-40	40%	16 %	-
	41-50	20%	32%	28%
	>50	10%	16%	14%
Marital Status	Married	70%	75%	72%
	Single	30%	25%	28%
Occupation	Housewife	10%	41%	-
	University student	-	-	28%
	Worker	10%	25%	14%
	Driver	-	8%	14%
	Clerk	10%	-	-
	Student	20%	8%	-
	Self-employed	50%	8%	28%
	Unemployed	-	-	14%
Location	Rural	10%	50%	28%
	Urban	90%	50%	72%

Table 4. Causes of carbon monoxide poisoning.

Causes of Incident	Frequency
Stovepipe was removed	1
Burning of coal (in tent)	1
Picnic gas stove	2
Leakage in stovepipe	1
Gas poisoning caused by DEPO exhaust	1
Heater outlet inside the home	2
Gas poisoning by kerosene heater	1
Removed chimney	2
Heater without a tube	1
Total	12

DISCUSSION

Common poisoning depends on the community's life style and social activities as well as chemicals available. Agricultural pesticide poisoning is common in some countries while in other countries drug toxicity and poisoning by narcotics are more common. Even the most common poisonings are diverse in different parts of a country. Causes of fatal poisoning are determined based on the results of toxicology in Departments of Forensic Medicine of each country. For instance, the highest poisoning leading to death is narcotic intoxication (41/3%) in Tehran and the second leading cause of death is carbon monoxide poisoning (23/3%) [14]. In this study, the carbon monoxide poisoning, after narcotic intoxication and aluminum phosphide, is ranked third. (Table 1) Among 237 people dying of poisoning in 2009, 2010 and 2011, 11.4% were poisoned by carbon monoxide, which, after narcotic intoxication and aluminum phosphide, was the third cause. This figure was significantly different in comparison with a study conducted in Tehran from 1994 to 1999. Because in the mentioned study death caused by narcotic intoxication had the highest rate and the second leading cause of death was carbon monoxide poisoning [15]. This difference is perhaps due to the widespread cultivation of rice, its storage in silos, the need to prevent pest damage by aluminum phosphide, and its vast supply in grocery stores in our area. But in developed countries, including the United States of America, carbon monoxide poisoning is ranked first. Unlike most of the previous reported studies [9, 10, 16, 17] that stated deaths caused by carbon monoxide poisoning are mostly in the elderly age group, in our study and another one done by Tofiqi et al. in Tehran, the frequency of deaths in younger age group (21 to 30 years) is more than that of other groups. The elderly and children made up a smaller percentage of deceased due to demographics, socio-cultural and economic structure of Iran. In the CO poisoning the age group of males is 1-62 years old and among females it is 7-77 years old. As it is shown, poisoning is not limited to a particular age group. However, some common types of poisonings in Iran, such as ethanol and methanol, the age range is limited [11]. In our study poisoning in males was higher than

females (1.7 times). This can be attributed to the fact that men have more job involvement, which is consistent with studies of Tofiqi et al. [14]. Males comprised 62.9% and females were 37.03% in these three years. An study in Tehran in 1999 showed that 33.6% of deceased were workers and 5.2% were drivers [14]. However, in this study most poisoning occurred among self-employed males and housewives. Forty percent of females died at home and 47.05% of males who died were self-employed. The type of device that causes poisoning was also different. The most common causes of death in other studies were wall-hung gas boilers (33.6%); however, the most common cause of poisoning in this study were heaters, and gas boiler made up a small percentage. In this study, 10% of death caused by poisoning was due to the use of picnic gas stove which corresponds with the study of Tofiqi et al. in Tehran. Evaluation of the results showed a significant relationship between location of poisoning and gender. As the death place of all women was at home or bathroom, the death of 41.17% of men had occurred at home and 29.5% outside the home. The majority of deaths happened in bed rooms and bath rooms. These places often lack a suitable ventilation system. The majority of poisonings were caused by heater at homes, due to the lack of awareness for the correct application of the device. As in other studies, [18] frequency of carbon monoxide poisoning was higher in cold seasons. Twelve cases (60%) happened at night and 8 events (40%) during the day. These findings were consistent with the study of Tofiqi et al. The most common source of CO used in all seasons was heater. However, in the study of Tofiqi et al., as well as another study conducted in Vienna, Austria in 1995, the most common source of fuel used in all months of the year was gas boiler [14, 19]. It shows lack of awareness on the correct use of the device as well a non-compliance with safety rules in our area, which require the development of programs to inform the public. Mortality among married people was more than singles in all 3 years. Khademi's study was consistent with this finding. Most cases occurred in cities (75%) and only (25%) in the villages. Perhaps this is because the corpses were not referred to the Department of Forensic Medicine in villages. Because of the development in gas distribution networks (more

than 60% of urban population), natural gas is the most common fuel and coal and petroleum are the second types of the consumed fuel. All cases examined in this study and other studies in Iran, were unintentional. This confirms the use of equipments with malfunction and failure to comply with safety requirements and standards [12] This finding was inconsistent with previous studies in developed countries [18-20]. Human exposure to air polluted with carbon monoxide gas makes his blood reach the equilibrium much faster and causes him to die sooner; the faster the rate of respiration, the sooner the reaching to the point of death. Breathing rate has a direct relationship with the relative body levels. The smaller the human is, the more the relative levels and the higher the respiration rate per unit of time will be; therefore one dies faster [21].

Also, due to the high number of respiration per unit of time in older people in comparison with younger people as well as factors such as heart and respiratory problems, they are more likely to die earlier [1, 21]. The results of this study were different from other countries; especially in terms of the factors that could cause carbon monoxide gas poisoning. Carbon monoxide gas emitted from vehicles is a major cause of poisoning deaths in the United States of America, but this was not a significant factor in this study. Most deaths due to carbon monoxide gas of vehicles occurred in garages with even open windows. This shows that perhaps the outlets was not enough to reduce the risk of living in a semi-closed site. Inhaling smoke from all types of fuels is the second leading cause of death from carbon monoxide gas [15, 16]. Crowley et al. reviewed poisoning in Ireland. Many poisonings occurred at home due to fire, but no fire has been reported in the present study. Forty people in Ireland die each year of carbon monoxide poisoning. Incomplete combustion of fuels caused some non-intentional fatal poisonings [22]. According to the results of this study, carbon monoxide poisoning, can be reduced through education and safety management strategies. Also, those who are associated with public health and health care should educate people on the risks of exposure to carbon monoxide gas resources.

CONCLUSION

According to a study conducted in our province, carbon monoxide gas poisoning is one

of the factors killing people every year, and what is certain is that ignorance and lack of information are the main cause of poisoning and mortality due to CO gas. It is, therefore necessary to consider the following factors:

1. It is necessary to educate and inform the public through media and educational institutions about the risks and sources of CO poisoning. Unfortunately, in recent years, warnings through media and education have become very small in television.
2. According to The results of this study, in more than half of the cases, the heater has been the cause of poisoning. Therefore, safety training in the field is required. Other studies have also found that some truck drivers in order to rest and avoid cold, use picnic gas stoves while sleeping, and this leads to their death. It should be noted that the picnic gas stove has no output to the environment and uses lots of oxygen that is a dangerous device in indoors with no ventilation.
3. Since bathrooms are usually small and do not have proper ventilation, gas-burning appliances should not be placed there. Unfortunately, in some houses, water heaters are still in the bathroom, which creates serious risks. This study also found that in 10% of cases who died from carbon monoxide gas boiler was used.

In addition to the above points, factors such as compliance with safety rules, standards in the flue gas piping for gas appliances, checking chimneys and gas hoses regularly, safe installation of heating equipment, safety training to the members of families and the use of gas heaters proportional to the area of room and apartment are important.

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