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ORIGINAL ARTICLE

A Yearlong Epidemiologic Study on Unintentional Acute Carbon Monoxide Poisoning in Fars Province, Southwest Iran

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Abstract

Background: Knowing the pattern of carbon monoxide (CO) poisoning in each region is vital for enhanced health planning. This study was designed to evaluate the epidemiologic pattern of unintentional acute CO poisoning in major cities of Fars province, southwest of Iran.
Methods: This one-year cross-sectional study was carried out on unintentional CO poisoning incidents in Fars province, Iran, during the year 2011. The target population was people living in 7 major cities under supervision of Shiraz University of Medical Sciences including Shiraz, Eghlid, Neyriz, Khorambid, Marvdasht, Darab and Bavanat.
Results: During 2011, 111 CO poisoning events occurred in the catchment area. These events involved 420 individuals (50.2% men) who were present during the poisoning event, of which 281 individuals with mean age of 27.8 ± 14.8 years were poisoned (46.5% men). The majority of CO poisoning events (77.3%) occurred in colder months of the year. Most events happened in urban areas (61.3%). The most common source of CO was water heater (27.5%) closely followed by gas stove (24.8%). The majority of poisoned patients were asleep during the event (150/281: 53.3%). The main causes of CO generation were inbound gas return (62.2%) and inappropriate ventilation (28.8%). The fatality rate of CO poisoning was significantly higher in men compared to women both in involved individuals and poisoned patients ($P = 0.035$, < 0.001; respectively). Moreover, poisoned victims who were asleep during the accident were more likely to die than those who were awake (14.3 vs. 3.7%, $P < 0.001$).
Conclusion: Generally, the incidence and fatality rate of CO poisoning in the current study were comparable to those of the world statistics, but higher than in developed counties. Attention and emphasis on the safety of gas heaters, stoves, and other gas-powered appliances in residential places should be enforced.

Keywords: Carbon Monoxide Poisoning; Epidemiology; Iran

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INTRODUCTION

Carbon monoxide is an odorless, colorless, toxic gas generated from incomplete fuel combustion in low concentrations of oxygen. The primary cause of CO poisoning is the lack of cellular oxygenation resulting from higher affinity of hemoglobin for CO than oxygen, which leads to high serum carboxy hemoglobin (COHb) (1,2). CO poisoning is typically unintentional and nowadays not caused by fire in majority of cases. CO poisoning manifestations vary from a simple headache to coma and even death (1,2). In minimal CO poisoning, unspecific symptoms such as headache, dizziness and nausea develop. In high-dose poisoning (above 150-200 ppm), disorientation, reduced consciousness and deep coma may occur (3). In long term, CO poisoning may leave chronic sequels especially on nervous system, which may present as amnesia, movement disorders, illusion, psychotic moods, disorientation, and urinary or stool incontinence (4,5).

Death following severe brain hypoxia is the worst case scenario for acute CO poisoning. Although CO poisoning is not generally common in Iran, deaths due to this type of poisoning is relatively high, especially when pre-hospital deaths are taken into account (6). According to epidemiologic reports from different parts of Iran, acute CO poisoning accounts for 0.4 to 1.7% of poisoning-related hospital admissions (7-9). Men and people aged 20 to 29 years are more involved with CO poisoning (7-9). However, the pattern

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of this type of poisoning varies region by region in Iran. Knowing the pattern in each region is vital for health authorities for improved planning in this regard. In this study, we aimed to evaluate the epidemiologic pattern of unintentional acute CO poisoning in major cities of Fars province, one of the largest provinces in Iran located in southwest of the country.

METHODS

Study design and catchment area

This one-year cross-sectional study was carried out on CO poisoning incidents in Fars province, Iran, during the year 2011. The target population was people living in 7 major cities under supervision of Shiraz University of Medical Sciences including Shiraz, Eghlid, Neyriz, Khorambid, Marvdasht, Darab and Bavanat. The cases of death due to CO poisoning were also obtained from regional office of Iranian legal medicine organization in Shiraz.

Data collection and inclusion/exclusion criteria

The data of unintentional CO poisoning incidents, not caused by previous intention or fire, were collected by reviewing the hospital records. Fire-related CO poisoning cases were excluded because of potential burn-induced comorbidities and lack of definite evidence to confirm the poisoning as the main cause of admission or death. CO poisoning was diagnosed by an officer of public gas supply office or by emergency physicians based on ventilation impairment along with incomplete combustion in the place of accident. Study variables including gender, age, situation and outcome of victims, cause, location, time and place of CO poisoning events were recorded for each case into a predesigned checklist. In addition to the documented data in emergency departments, some data were also gathered by telephone interviews with the poisoned individuals or their families (in case of death) and the records of legal medicine organization, as well. The telephone interviews were helpful in identifying the number of family members or friends or coworkers who were present in each event. In general, the information was gathered from two groups: those who were present at the location of the accident and involved mildly without receiving any medical intervention, and those who were poisoned. In Iran, nearly all CO poisoning cases, regardless of their severity, are reported as emergency to regional health authorities; however, as we attempted to miss no case, the records from the legal medicine organization were also reviewed, and so all unintentional CO poisoning cases in 2011 were finally included in our analysis.

Statistical analysis

In the current study, 2011 official information distributed by Statistical Centre of Iran was utilized in order to calculate the CO poisoning incidence rate per population. Data were analyzed using Microsoft Excel (Microsoft Corp., Redmond, WA, USA). Results are expressed with frequency and percentage, and are shown with descriptive graphs. To compare the frequency of observations between two groups, chi-squared test was used. P values less than 0.05 were considered to be statistically significant.

RESULTS

During 2011, 111 CO poisoning events occurred in the catchment area. These events involved 420 individuals who were present during the poisoning event, of which 281 individuals with mean age of 27.8 ± 14.8 years were poisoned. The frequency distribution of CO poisoning cases, plotted against the city of event, is shown in table 1.

The monthly distribution of CO poisoning cases is provided in Figure 1. As can be seen, the majority of CO poisoning events (77.3%) occurred in colder months of the year.

The majority of CO poisoning events happened in urban areas (61.3%) and in residential buildings (77.5%) (Table 2). The most common source of CO (CO generator) was water heater (27.5%) closely followed by gas stove (24.8%). The fuel type in the majority of cases (63.7%) was "natural gas".

The main causes of accidental CO generation were inbound gas return (62.2%), inappropriate ventilation (28.8%), and heater misuse (17.1%) (Table 3). It should be noted that in some events, the technical reason for CO generation could be attributed to two factors or more.

Table 1. CO poisoning cases plotted against city of event in Fars province, Iran, 2011

	CO poisoning events		Poisoned patients	
City	N (%)	Annual cumulative incidence rate (per 100,000 population)*	N (%)	Annual cumulative incidence rate (per 100,000 population)*
Shiraz	91 (82.0)	5.4	237 (84.3)	13.9
Eghlid	3 (2.7)	3.2	10 (3.6)	10.6
Neyriz	4 (3.6)	3.5	8 (2.8)	7.0
Khorambid	1 (0.9)	2.0	3 (1.1)	6.0
Marvdasht	6 (5.4)	1.9	14 (5.0)	4.6
Darab	5 (4.5)	2.6	6 (2.1)	3.2
Bavanat	1 (0.9)	2.1	3 (1.1)	6.2
Total	111 (100)	4.4	281 (100)	11.2

* The population number of each city was derived from the 2011 national census performed by the Iranian Statistical Centre

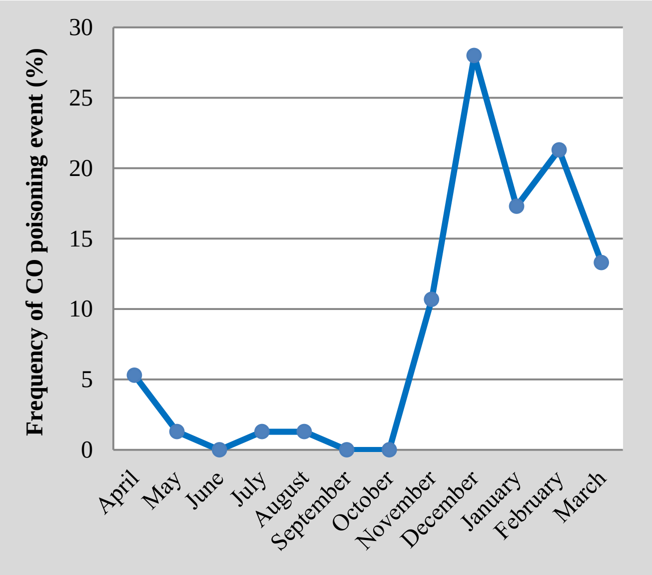

Figure 1. Frequency of CO poisoning events (%) by month in Fars province, Iran, 2011

Among 420 individuals who were present during the incidents, 50.2% were men and among 281 poisoned cases, 53.5% were women (Figure 2). The majority of poisoned patients were asleep during the event (150/281: 53.3%).

The fatality rate of CO poisoning was significantly higher in men compared to women both in involved individuals and poisoned patients (P = 0.035, < 0.001; respectively) (Table 4). Moreover, poisoned victims who were asleep during the accident were more likely to die than those who were awake (P < 0.001).

DISCUSSION

In this study, 111 CO poisoning events, in which 281 people manifested specific symptoms of CO poisoning, were analyzed. This gave an annual cumulative incidence rate of 11.2 per 100,000 population of the catchment area. This rate is higher than the incidence rate of unintentional CO poisonings in Tabriz, northwest of Iran, which was 9.2 per 100,000 people as estimated by Nazari et al (10), and much higher than the incidence rate of CO exposures in Mashhad, northeast of Iran, which was 1.9 per 100,000 people as appraised by Khadem-Rezaiyan and Afshari (8). As fossil fuel heating devices are used more frequently in the winter (2,11), CO poisoning accidents were more common in this season, especially in colder cities of the catchment area. In such cases, the technical deficiency of heaters and poor ventilation at first use increases the probability of CO poisoning. Moreover, the frequency of CO poisoning was greater in urban areas (61.3%) than that in rural areas. Nonetheless, living in a city is not a deterministic factor for CO poisoning given that a larger percentage of the Iranian population (62% according to the2011 census) lives in urban areas. In addition, the majority of CO poisonings happened at houses and apartments and less commonly in the workplace.

Table 2. Location of event and CO source in CO poisoning cases

Variables	N (%)
Place of residence	
Urban	68 (61.3)
Rural	34 (30.6)
Outside the urban or rural areas (e.g. roads)	9 (8.1)
Place of accident	
House	67 (60.4)
Apartment	19 (17.1)
Car	5 (4.5)
Workplace	4 (3.7)
Camp	4 (3.7)
School	1 (0.9)
Other	11 (9.9)
Location of accident in house/apartment	
Bedroom	40 (46.5)
Living room	28 (32.6)
Kitchen	4 (4.7)
Other	5 (5.8)
Unknown	9 (10.5)
CO generator	
Water heater	30 (27.5)
Gas stove	27 (24.8)
Tank heater	10 (9.3)
Wall gas stove	9 (8.3)
Brazier	9 (8.3)
Oil heater	7 (6.4)
Gas grill	7 (6.4)
Gas oven	5 (4.5)
Gas light	4 (3.6)
Chimney	1 (0.9)
Unknown	2 (1.8)
Fuel type*	
Natural gas	72 (63.7)
Liquid gas	22 (19.5)
Coal	9 (8)
Oil	7 (6.2)
Wood	3 (2.6)

* In two events, two fuel types were involved

A study in a western province of Iran supports these results (12).

In the United States, the majority of CO gas responsible for poisoning was found to be generated from electricity generators (55.6%) followed by heaters (23.1%). Moreover, most CO Poisonings were found to occur at homes (93.5%) and the remaining cases occurred in workplaces (6.5%) (13). Lack of a warning alarm system in residential buildings and workplace in addition to absence of periodic safety checks of

Table 3. Technical reasons for CO generation

Parameter	N (%)
Inbound gas return	68 (61.2)
Funnel disconnection	34 (30.6)
Funnel obstruction	13 (11.7)
Impaired heating appliance	5 (4.5)
Thin obstruction of vent pipe	4 (3.6)
Shared heater vent pipe	1 (0.9)
Low height vent pipe	1 (0.9)
Vent pipe in a closed area	1 (0.9)
Unexplained or mixed reasons	16 (14.4)
Inappropriate ventilation	32 (28.8)
Insulated room with closed door	29 (26.1)
Insulating the seams around the door	21 (18.9)
Completely enclosed windows	7 (6.3)
Double glazed windows with no safety valve*	1 (0.9)
Heater misuse	19 (17.1)
Use of oven for making the living space warm	13 (11.7)
Big heater in a small space	1 (0.9)
Unexplained or mixed reasons	8 (7.2)

* Air exchange with the outside is almost none when using double glazed windows. According to standards, for buildings that use double glazed windows, a safety valve should be embedded in the adjacent wall for better ventilation.

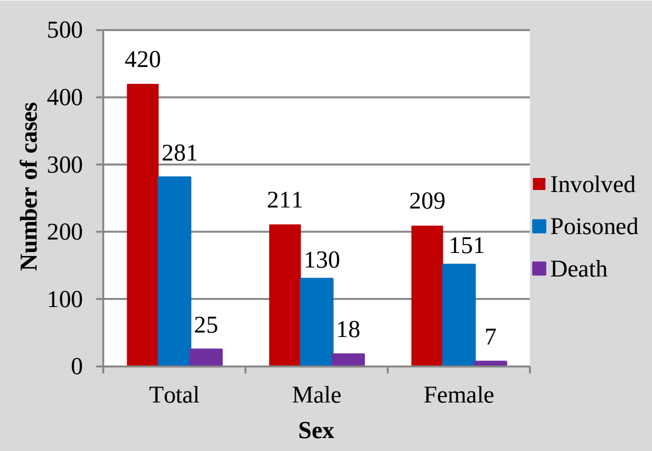

Figure 2. Frequency of people inovlved, poisoned, or died in CO poisoning events divided by gender

these systems may increase the risk of CO poisoning (14,15). Moreover, low quality control during building construction (inappropriate establishment of vent pipe for fuel-operated appliances) and lack of knowledge about proper use of heaters are also important factors for CO poisoning. It is highly noted that public education, installation of warning alarms and periodic checks of these systems, can be helpful in prevention of CO poisoning (16,17). In this respect, as the quality of the indoor air is important, the World Health Organization has released some standards for it, as well as measures to be taken to increase safety and awareness (17).

CO poisoning is one of the important causes of sudden death in the United States (14,16,18,19), resulting in approximately 40,000 emergency admissions to hospitals annually and a major cause of poisoning-related deaths (19). The United States' Center for Disease Control and Prevention has estimated that over 2000 people die annually in this country as a result of CO poisoning (20). A recent study in the United States showed that the fatality rate of CO poisoning was 4% in that country, which is lower than the death rate found in this study and equals to approximately half of our death rate (8.9%) (13). Although the fatality rate of CO poisoning is variable in different countries and in general is less than 5% (2,21,22), developed countries are more prepared in taking preventive actions, having warning alarms systems and advanced medical care such as hyperbaric oxygen chambers. In this study, we showed that CO poisoning is more fatal if the victim is not alert and is sleeping. Hence, it is logic to promote installation of warning alarm systems at homes that can greatly reduce fatalities (23).

LIMITATIONS

Since there is no integrated, shared system to record CO poisoning incidences, obtaining data about such occurrences was a challenge and a major limitation of this study. Previous data gathering techniques neglected to include all aspects of the poisoning event from the beginning to the outcome. For this study, the authors developed a checklist which contained all related variables of CO poisoning. However, because most of the CO poisoning symptoms are unspecified or unrecognizable, this report might potentially underestimate CO poisoning episodes. On the other hand, in some cases other poisonings might be categorized as CO poisoning, as John Wright pointed out this fact in his paper (24). Nonetheless, in this study, we tried to include cases that were absolutely confirmed to have CO poisoning. Another limitation of the study was that the CO concentration could not be measured in the air of the location of incident. In addition, COHb level was not measured for all poisoned victims and so the related analysis was not mentioned in the text.

Table 4. Case fatality rate (%) divided by gender and awakeness of subjects

Subjects	Total death rate	Death rate by gender		P value	Death rate by awakeness		P value
		Male	Female		Asleep	Awake	
Involved	5.2	8.5	3.3	0.035	---	---	---
Poisoned	8.9	13.8	4.6	< 0.001	14.3	3.7	< 0.001

CONCLUSION

Generally, the incidence and fatality rate of CO poisoning in the current study were comparable to those of the world statistics, but higher than in developed counties. Attention and emphasis on the safety of gas heaters, stoves, and other gas-powered appliances in residential places should be enforced. It is crucial to evaluate the function and quality of these appliances and to ensure their proper ventilation, especially at beginning of the cold months and when moving to a new house.

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