**ORIGINAL ARTICLE**

# Carbon Monoxide Poisoning in the Region of Fez-Boulemane, Morocco: Epidemiological Profile and Risk Factors (2009-2012)

AWATEF TAHOURI[1], BADIAA LYOUSSI[1], SANAE ACHOUR[2,3,*]

[1] Physiology-Pharmacology and Environmental Health Laboratory, Department of Life Sciences, Dhar El Mahraz Faculty of Sciences, Sidi Mohamed Ben Abdallah University, Fez, Morocco
[2] Faculty of Medicine and Pharmacy, Sidi Mohamed Ben Abdallah University, Fez, Morocco
[3] Toxicology Unit, Central Laboratory of Medical Analysis, Hassan II University Hospital, Fez, Morocco

## Abstract

*Background:* Carbon monoxide (CO) poisoning has remained a common, serious and often unrecognized event and constitutes a public health problem in Morocco. The objective of this study is to describe the epidemiological and clinical profile and risk factors of CO poisoning in the region of Fez-Boulemane, Morocco.
*Methods*: This is a retrospective study on CO poisoning cases occurred in the region of Fez-Boulemane between January 2009 and December 2012. Data were retrieved from medical records of patients who were admitted to 7 referral hospitals in the study catchment area. The patient's clinical status was classified according to the Poisoning Severity Score. By comparing critical (grade 3 or 4) and non-critical (grade 1 or 2) cases, a univariate analysis was performed to identify the factors associated with life-threatening consequences.
*Results:* During the study period, 2332 cases were included. Most patients were women (68%). The mean (SD) age of patients was 26.4 (16.1) years. Most cases occurred during winter (45.1%). The source of poisoning was water heaters in majority of cases (53%). The most common manifestations were headache in 86%, nausea in 79%, dizziness in 76%, vomiting in 63% and dyspnea in 63% of cases. The majority of patients had grade 2 or grade 1 poisoning severity. Univariate analysis demonstrated that gender (P = 0.03) and the location of event (P = 0.005) had significant impacts on the prognosis while age did not have any influence on the severity of poisoning (P = 0.15). The impact of season of event on the prognosis approached the level of significance but its significance was questionable (P = 0.09).
*Conclusion:* This study showed that CO poisoning is common but probably underestimated in the region. Strengthening the role of the morocco poison control center in the region would be the most effective preventive measure to decrease morbidity and mortality secondary to CO poisoning.

**Keywords:** Carbon Monoxide Poisoning; Epidemiology; Morocco; Risk Factors; Prognosis

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## INTRODUCTION

Poisoning by carbon monoxide (CO) is one of the most common types of fatal poisoning in many countries (1-3). In Morocco, it has remained a common, serious and often unrecognized event and constitutes a public health problem (4,5).

CO gas is odorless with initially non-irritating properties, providing its inhalation in high concentrations and is potentially lethal without warning symptoms for the victim (1). It causes multiple symptoms and is often under-diagnosed (1,5-7). Generating sources of CO include incomplete combustion of carbon containing substances, smoking, fire and vehicle exhaust (2, 8). The circumstances of poisoning are diverse and often unintentional. It occurs frequently in homes but also in workplaces. Enclosed spaces and confined environments are aggravating factors for all of these sources. The symptomatology of CO poisoning is insidious and multifaceted that makes its diagnosis difficult. The management is based primarily on the speedy use of normobaric and/or hyperbaric oxygen (6,7).

The objective of this study is to describe the epidemiological and clinical profile, and risk factors of CO poisoning in the region of Fez-Boulemane.

## METHODS

This is a retrospective study on CO poisoning cases occurred in the region of Fez-Boulemane for a period of four years (between January 2009 and December 2012). Morocco is geographically divided into 16 regions which Fez-Boulemane (Fès-Boulemane) is one of them (Figure 1). It is located in north of Morocco and covers an area of 19,795 km² and possess a population of 1,573,055 people based on general Moroccan census of population in 2004.

In this study, data including demographic features, circumstances of events, symptomatology and outcome were retrieved under the supervision of Regional Health Directorate from medical records of patients who were

*Correspondence to: Sanae Achour, MD. Associate Professor of Toxicology, Faculty of Medicine and Pharmacy, Sidi Mohamed Ben Abdallah University, Fez, Morocco.
Tel: +21 266 142 1282, E-mail: achoursanae@gmail.com
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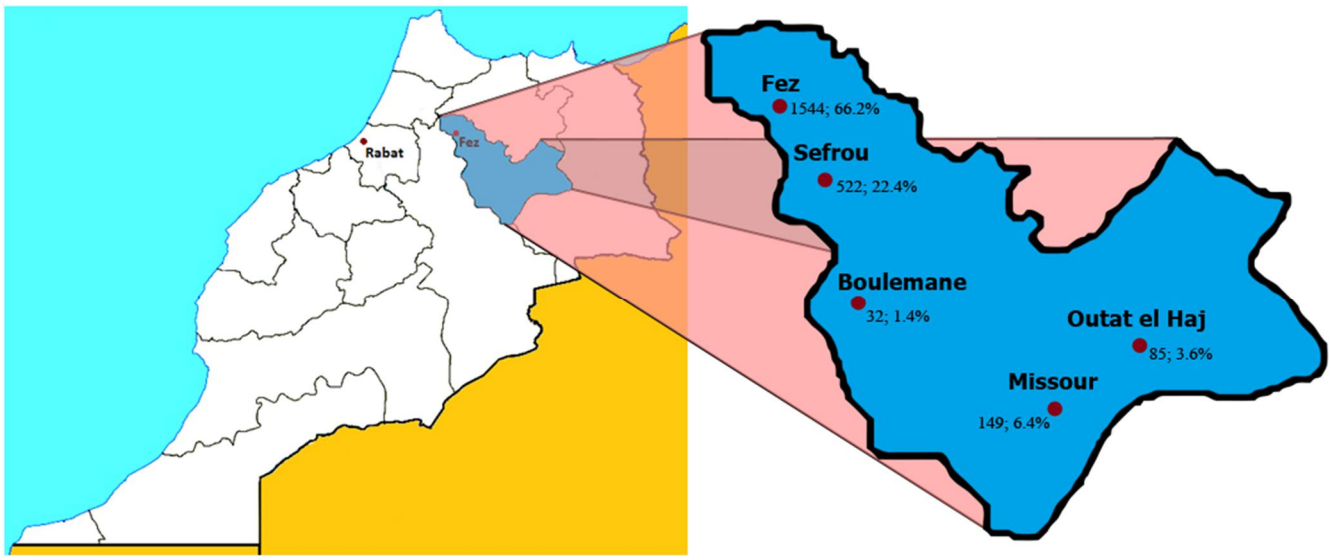


**Figure 1.** Map of Fez-Boulemane region with statistics of Carbon Monoxide Poisoning (n = 2332). Frequency of CO poisoning cases in each city and percentage of total are shown next to red spots.

admitted to 7 referral hospitals in the study catchment area. The patient's clinical status was classified according to the Poisoning Severity Score (9). Based on this scale, poisoned patients can be classified as minor or grade 1 (mild, transient and spontaneously resolving symptoms), moderate or grade 2 (marked or prolonged symptoms), severe or grade 3 (severe or life-threatening symptoms) and fatal or grade 4. By comparing critical (grade 3 or 4) and non-critical (grade 1 or 2) cases, a univariate analysis was done to identify the factors associated with life-threatening consequences.

The age groups used in this study were according to recommendations of International Program on Chemical Safety. The data were analyzed using Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA).

## RESULTS

*Demographic Features*

Between January 2009 and December 2012, 2332 cases of CO poisoning were collected. Most patients were women (68%). The mean (SD) age of patients was 26.4 (16.1) years. Based on age groups, the majority of patients (62.2%) were adults (20-74 years), followed by children aged 5 to 14 years (21.1%) and adolescents aged 15 to 19 years (13.3%).

*Characteristics of events*

The greatest proportion of cases (62.5%) took place in urban areas (Table 1). Unintentional exposure was the main cause of poisoning which was observed in 99% of cases. The majority of poisonings occurred at homes (97.8%), while in public places and work places less than 1% of cases occurred. The geographical distribution of events showed predominance of Fez city followed by Sefrou city (Figure 1). CO poisoning involved only one episode and involved multiple victims in 39.5% of episodes. During the study period, the highest number of cases occurred in 2010 (Figure 2). Regarding seasonal distribution of events, most cases occurred during winter (45.1%) followed by fall (28.4%), spring (19.1%) and summer (7.4%) (Figure 3). In a more detailed look, monthly distribution of cases peaked in December (Figure 4). CO poisoning occurred predominantly on weekends. The source of poisoning was found to be water heaters in 53% of cases and braziers in 23% of cases.

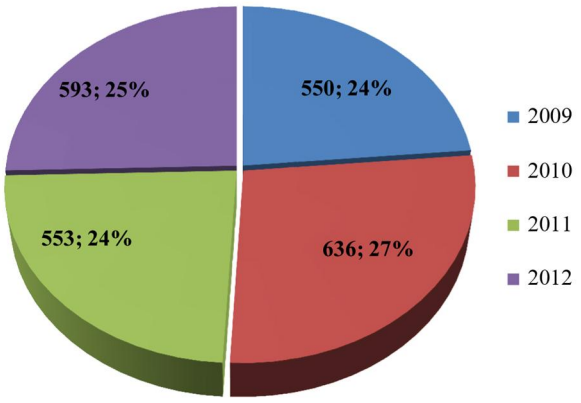


**Figure 2.** Annual frequency of CO poisoning cases in the Fez-Boulemane region

**Table 1.** Analysis of impact of demographic and event parameters on prognosis of carbon monoxide poisoning

| Parameter | Total | Critical (n = 63)* | Non-critical (n = 2269)** | P value*** |
|---|---|---|---|---|
| Gender, n (%) | | | | |
| Female | 1585 (68.0) | 35 (55.5) | 1550 (68.3) | 0.03 |
| Male | 747 (32.0) | 28 (44.5) | 719 (31.7) | |
| Age group (year), n (%) | | | | |
| <1 | 14 (0.6) | 1 (1.6) | 13 (0.5) | 0.15 |
| 1-4 | 59 (2.5) | 1 (1.6) | 58 (2.5) | |
| 5-14 | 492 (21.1) | 9 (14.2) | 483 (21.3) | |
| 15-19 | 311 (13.3) | 11 (17.5) | 300 (13.3) | |
| 20-74 | 1450 (62.2) | 40 (63.5) | 1410 (62.2) | |
| >75 | 6 (0.3) | 1 (1.6) | 5 (0.2) | |
| Season, n (%) | | | | |
| Spring | 447 (19.2) | 6 (9.5) | 441 (19.5) | 0.09 |
| Summer | 162 (7.0) | 8 (12.7) | 154 (6.8) | |
| Autumn | 672 (28.8) | 18 (28.6) | 654 (28.8) | |
| Winter | 1051 (45.0) | 31 (49.2) | 1020 (44.9) | |
| Location of event, n (%) | | | | |
| Urban | 1458 (62.5) | 50 (79.4) | 1408 (62.1) | 0.005 |
| Rural | 874 (37.5) | 13 (20.6) | 861 (37.9) | |

* Patients with grade 3 or 4 of poisoning severity
** Patients with grade 1 or 2 of poisoning severity
*** Analyzed with chi-square test

*Clinical findings and treatment*

All cases were symptomatic at presentation. The symptomatology was characterized by the predominance of neurological signs including headache in 2023 cases (86%) and dizziness in 1772 cases (76%), followed by nausea in 1845 cases (79%), vomiting in 1470 cases (63%) and dyspnea in 1473 cases (63%) (Table 2). During the study period, the severity score was determined in 59.6% of cases. The majority of patients had grade 2 or grade 1 poisoning severity (Table 2). Normobaric oxygen therapy was the main treatment that was administered to all patients.

*Outcomes and risk factors*

The outcome for the patients was favorable in the vast majority of cases (98.2%), while only 0.5% of cases developed neurological sequel and death occurred in 1.3% of cases.

Univariate analysis by comparing critical (grade 3 or 4) and non-critical (grade 1 or 2) cases demonstrated that gender (P = 0.03) and the location of event (P = 0.005) had significant impacts on the prognosis while age (P= 0.15) did not have any influence on the severity of poisoning (Table 1). The impact of season of event on the prognosis approached the level of significance but its significance was questionable (P = 0.09).

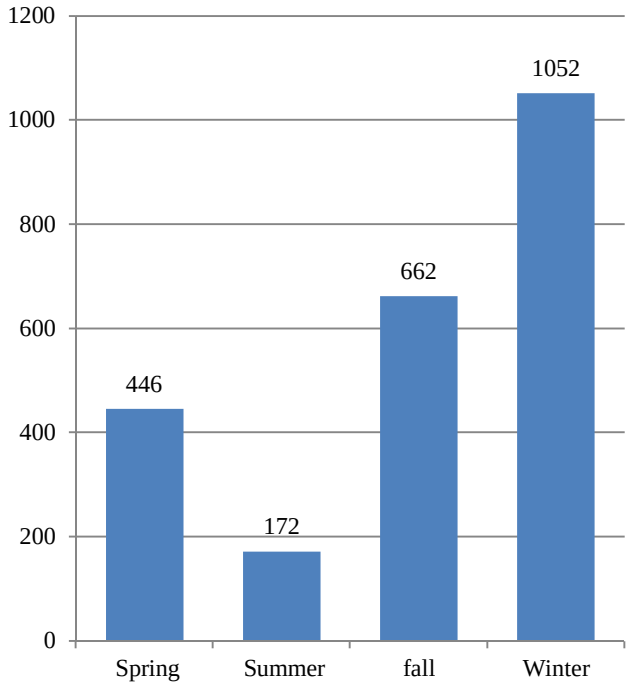


**Figure 3.** Seasonal frequency of CO poisoning cases in the Fez-Boulemane region.

**Table 2.** Clinical findings and severity of poisoning in CO poisoned patients in the Fez-Boulemane region from January 2009 to December 2012 (n = 2332).

| Variable | n (%) |
|---|---|
| Clinical Findings | |
| Headache | 2023 (86.7) |
| Nausea | 1845 (79.1) |
| Dizziness | 1772 (75.9) |
| Dyspnea | 1473 (63.1) |
| Vomiting | 1470 (63.0) |
| Weakness | 100 (4.3) |
| Loss of consciousness | 39 (1.7) |
| Dysrythmia | 12 (0.5) |
| Myocardial infarction | 5 (0.2) |
| Severity of poisoning | |
| Grade 1 | 946 (40.5) |
| Grade 2 | 1323 (56.7) |
| Grade 3 | 34 (1.4) |
| Grade 4 | 29 (1.2) |

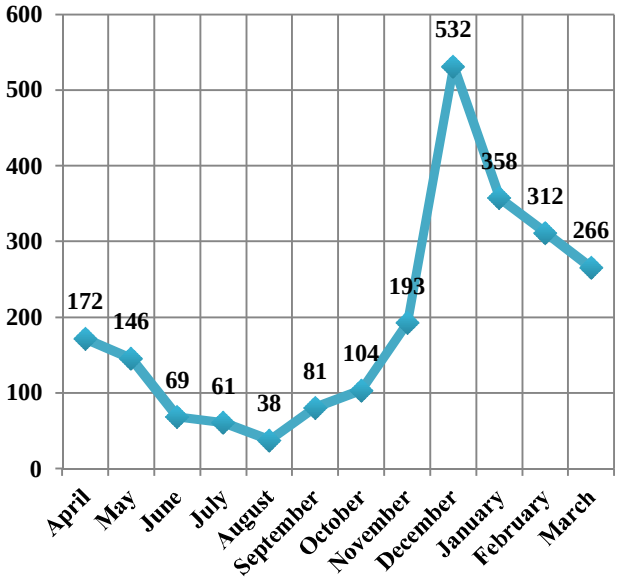


**Figure 4.** Monthly frequency of CO poisoning cases in the Fez-Boulemane region

## DISCUSSION

CO poisoning continues to be one of the most common environmental poisoning throughout the world (1-4,8). Poison control center of Morocco (MPCC) reported 18379 cases of CO poisoning who were guided by the MPCC during 1980 to 2011 (4). In the region of Fez-Boulemane, we studied 2332 cases between January 2009 and December 2012 with 1.3% mortality, however, this number does not reflect the real extent of the problem. This is because some patients died at home or on route to the hospital and their data were not entered into hospital records. Moreover, asymptomatic cases do not seek consultation and also unfamiliarity with CO poisoning provides frequent confusion with other diseases (1,5). These factors can lead to under reporting.

In the United States, 439 deaths due to unintentional, non-fire-related CO poisoning occurs annually which implicates about 2% mortality rate (2). France has reported 300 deaths related to CO poisoning annually. In 2010, 1509 episodes of CO poisoning were notified in Alsace-Lorraine region, which involved 5,195 people. 3,413 of them were transported to local hospital emergency departments, and 1,136 of them were hospitalized (12). In Iran, 257 cases of CO poisoning were reported with less than 1% mortality.

Our sample is characterized by the predominance of young patients, which may be partially explained by the "Moroccan population pyramid" that mostly includes people at young ages, and also by the fact that this age group is the active population which is often the victim of occupational toxic exposures (13). In the present study, we found that gender and location of event are two significant factors of causing more life-threatening consequences. Women were predominant in CO poisoning which could be explained by the fact that most women are housewives and are often not aware of certain risky actions related to CO production. Furthermore, most cases occurred in urban areas which could be due to the weather conditions and also being exposed to more dangerous sources of CO such as exhaust fumes in industries (13). The common cause of CO poisoning in rural areas could be the abundance of forest areas, which facilitates the use of wood and coal as the main source of heating (14).

In this study, the seasonal pattern showed an increase in winter and fall. The impact of seasonal distribution of events on prognosis approached significance, though its significance was questionable. In this regard, cases that occurred in winter were more severe. This also ascertains the prominent role of factors associated with heating including heating appliances particularly gas heaters, braziers (Kanoun) and gas water heaters (8,15,16). In addition, employment of these appliances accompanies an imminent risk, mainly in confined spaces (1,8). Even in summer, it is not safe from CO poisoning as we found 7.4% of cases occurred in this period. This suggests the other sources of CO generation such as fire, exhaust fumes and smoke in public baths as the reasons of poisoning (8). In this study, CO poisoning cases occurred in an almost homogeneous number for every day of the week except Sunday when there was an increase. This is the day of the week when people stay at home, cook with Kanoun and camping gas and use heating appliances including water heaters in higher extent (14,17). Thus, home was the main place of occurrence of CO poisoning.

Acute CO poisoning is symptomatic in most cases (1). The clinical manifestations of CO poisoning are polymorphic, making diagnosis difficult. There is no specific sign or symptom which occasionally misleads physicians to other commonplace diagnoses such as common cold. Sometimes, CO poisoning is manifested with nausea and vomiting which can be confused with food poisoning (6,7). The majority of neurologic and cardiac manifestations that are produced through CO poisoning reflect the sensitivity of these organs to oxygen deficit. In this study, symptomatology was characterized by the predominance of neurological symptoms with primarily headache and dizziness.

The disease course in CO poisoning is generally towards full recovery, especially if timely treatment with oxygen, either normal or hyperbaric, according to the clinical severity was given to the patients (6,7,18,19). However, late-onset neurological sequelae may develop if early proper treatment is delayed (8,18). In the present study, only 0.5% of patients developed neurological sequelae. In a study by Iseki et al, neurological sequelae were found in 6% of Japanese citizens who were poisoned with CO after the Great East Japan Earthquake (8). Only early treatment (less than 6 hours post-exposure) with supplemental oxygen can reduce the dangerous consequences (20).

## LIMITATIONS

Although supplemental oxygen therapy is the cornerstone of treatment of CO poisoning, hyperbaric oxygen therapy which is more effective may not be available in all emergency departments. In the absence of hyperbaric therapy in most parts of the Morocco, including the region of Fez-Boulemane, the management performed in this study was based primarily on normobaric oxygen. Moreover, in this study, the data were collected retrospectively with review of medical records. Given that some details may have been missed from being entered into medical records, bias in data collection could be another limitation.

## CONCLUSION

This study showed that CO poisoning is common but probably underestimated in our region. Some countries have now mandated the installation of CO detectors in residential areas, along with smoke detectors and fire alarms (21), but further studies are needed to evaluate the effectiveness of these instruments. Strengthening the role of poison control centers, particularly the MPCC in our region, remains the most effective preventive measure to decrease morbidity and mortality secondary to CO poisoning.

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