

## Retrospective study of health indicators related to carbon monoxide poisoning in Morocco

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**ABSTRACT:** The objective of this study is to measure the state of health of the population of Morocco regarding carbon monoxide (CO) poisoning based on the evolution over time and space of health indicators.

A retrospective analytical study of health indicators related to carbon monoxide poisoning, i.e. incidence, mortality, and lethality at the regional and national population level during the period 1999 to 2013.

The evolution over time of the incidence shows continuous growth at the national level. The highest average is thus observed in the region of Meknes-Tafilalt (0.112 per 1000 inhabitants).

Regarding mortality indicators, the evolutionary study reveals overall continuous growth over time at the national level. At the regional level, we note annual fluctuations in rates in virtually all regions and case fatalities record the highest averages in the regions of Fez-Boulmane, Gharb-Chrarda-Beni Hssen, Rabat-Salé-Zemmour-Zaer, Doukkala-Abda, and Souss-Massa-Draa.

The study highlights, on the one hand, that CO poisoning in Morocco is mainly influenced by weather conditions. Indeed, regions characterized by autumn and especially cold winter temperatures record the highest incidences. On the other hand, the fatal risk in the event of poisoning does not depend on the incidence at the level of regional populations, and the chronological evolution of mortality and case fatality rates at the national level is rather dependent on the unforeseeable accidental nature of the occurrence of deaths.

**KEYWORDS:** Poisoning, carbon monoxide, incidence, mortality, lethality, Morocco.

### 1 INTRODUCTION

Each year, a significant number of unintentional carbon monoxide poisonings are found to be linked mainly to gas characteristics and human recklessness [1], [2], [3], [4]. These poisonings are at the origin of hundreds of hospitalizations and represent the cause of many deaths in Morocco [5], [6], [7], [8], [9], [10]. This poses a real public health problem.

Despite efforts through the national strategy to combat carbon monoxide poisoning, the figures remain alarming. It is therefore important to further develop knowledge of all aspects of the epidemic to find ways to better understand its morbidity and mortality.

This study of the chronological and spatial evolution of health indicators related to CO poisoning in Morocco proposes to deepen scientific investigations for a better understanding of all aspects of this epidemiological phenomenon and to serve as a support for raising awareness of its severity.

### 2 DATA AND METHODS

The measurement of the health status of the population, through the analysis in time and space of the incidences, lethality, and mortality related to CO poisoning, is based on the CAPM database formed by the collection of reports using the two information systems: toxicovigilance and toxicological information.

The analysis of the data and their exploitation is carried out using the Epi-Info and Excel software. The determination of the rates of the indicators is based on the censuses, the retro projections and projections of the population, and the national demographic survey with repeated passages of 2009-2010, established by the High Commission for the Plan of Morocco [11].

The thematic cartographic visualization of the regional distribution of the indicators studied is carried out thanks to the geographic information system.

### 3 RESULT

Several epidemiological, clinical and evolutionary studies of CO poisoning in Morocco focus on its origins and severity [5], [6], [7], [8], [9], [10], [12], [13].

During the period 1999-2013, the CAPM recorded 20,683 cases of CO poisoning. This represents 20.24% of all poisonings reported during the same period nationwide. The seasonal nature is undeniable. Indeed, 72% of cases are recorded in autumn and winter, with a winter resurgence. We also note an increasing and continuous increase in frequency over time which is explained by the increase in declarations and the reckless behavior of the population in the use of poor quality or faulty water heater systems (43% of cases) [12].

#### 3.1 EVOLUTION OF THE INCIDENCE

The analysis of the regional average impacts of the period 1999-2013, which has already been the subject of previous work, reveals that the highest incidence observed is in the Meknes-Tafilalt region (0.1125 ‰), followed by the Tadla-Azilal region (0.0868 ‰) [12].

The annual evolution of the incidence during the period 1999-2013, illustrated by Figure 1, shows growth over time, despite slight decreases between 1999 and 2002 (from 0.025‰ in 1999 to 0.0227‰ in 2002), between 2006 and 2007 (0.0433‰ in 2006 and 0.0406‰ in 2007) and between 2012 and 2013 (0.0912‰ in 2012 and 0.0736‰ in 2013). In addition, the incidence recorded in 2012 represents the maximum value observed during the entire study period [12].

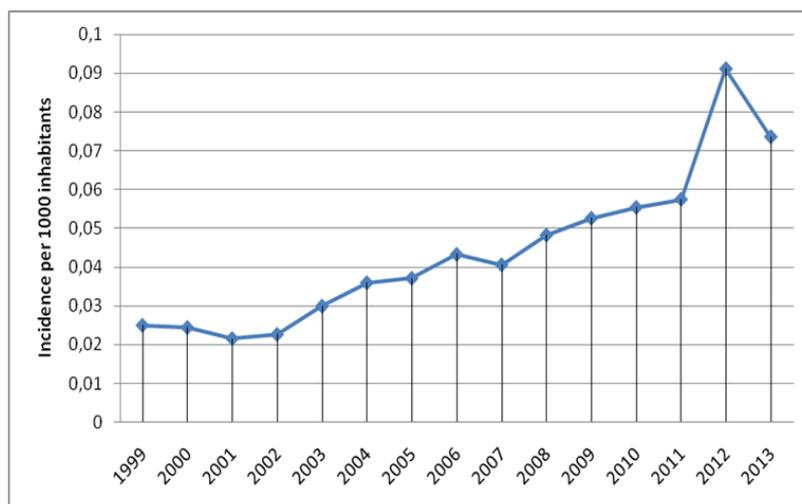


Fig. 1. Annual distribution of incidences of CO poisoning during the period 1999-2013 in Morocco [12]

#### 3.2 EVOLUTION OF MORTALITY

The evolution of regional mortalities associated with CO poisoning, illustrated in Figure 2, highlights four subdivisions according to the vital impact of gas at the regional level:

- The regions of Oriental, Meknes-Tafilalt, and Fez-Boulmane are the most marked by deaths and therefore record the highest average mortality rates

Indeed, the Oriental region, with 31 deaths during the 15 years studied, recorded the highest mortality at the national level (0.103 per 100,000 inhabitants). It is important to note, however, that this value is estimated from the cases of death that occurred between 2007 and 2013 as no deaths are reported before this period. This suggests that mortality at the regional level is likely underestimated [13].

The region of Meknes-Tafilalt, meanwhile, reports the most cases of death at the national level because of CO during these 15 years, or 32 cases. This high numerator indicates high mortality, i.e. 0.096 per 100,000 inhabitants. This result seems quite likely since the population of the region is assumed, by its climate, more exposed to the risk of CO poisoning [13]. In the region of Fez-Boulmane, the impact of poisonings is relatively less important compared to previous regions. Nevertheless, given the 23 deaths reported during the study period, the average mortality remains relatively high (0.0898 per 100,000 population). However, we note that, except for 2 deaths that occurred in 2004, all deaths are concentrated between 2008 and 2013, which suggests that there is no underestimation of mortality.

- The second subdivision corresponds to the regions with lower average mortality, between 0.03 and 0.05 per 100,000 inhabitants: Taza-Al Hoceima-Taounate (0.047 per 100,000), Tangier-Tetouan (0.042 per 100,000), Rabat-Salé-Zemmour-Zaer (0.04 per 100,000), Gharb-Chrarda-Beni Hssen (0.038 per 100,000) and Marrakech-Tensift-Al Haouz (0.034 per 100,000). These values are not attributable to regularly recorded numerators, but a concentration of deaths in certain years [13]. It is also important to stress that cases of deaths not reaching the CAPM can influence these mortality rates, especially in the regions of Taza-Al Hoceima-Taounate, Tangier-Tetouan, and Marrakech-Tensift-Al Haouz where the frequency of CO poisoning must be high, in principle.
- The third subdivision refers to regions where mortality associated with CO does not exceed 0.02 per 100,000 inhabitants, namely Doukkala-Abda (0.02 per 100,000), Souss-Massa-Drâa (0.016 per 100,000), Tadla-Azilal (0.014 per 100,000), Greater Casablanca (0.013 per 100,000) and Chaouia-Ouardigha (0.008 per 100,000). It should be noted that within the Tadla-Azilal region, only 3 cases of death have been reported during the 15 years in a region known for its freezing winter seasons and the inaccessibility of some municipalities during snowy periods. This raises the question of whether all cases of death reach the CAPM and therefore whether the actual mortality is not higher.
- The fourth subdivision relates to the Saharan regions: Guelmim-Es Semara, Laayoune-Boujdour-Sakia El Hamra and the region of Oued Ed Dahab-Laguira do not record any cases of death during the entire period studied, so mortality is zero.

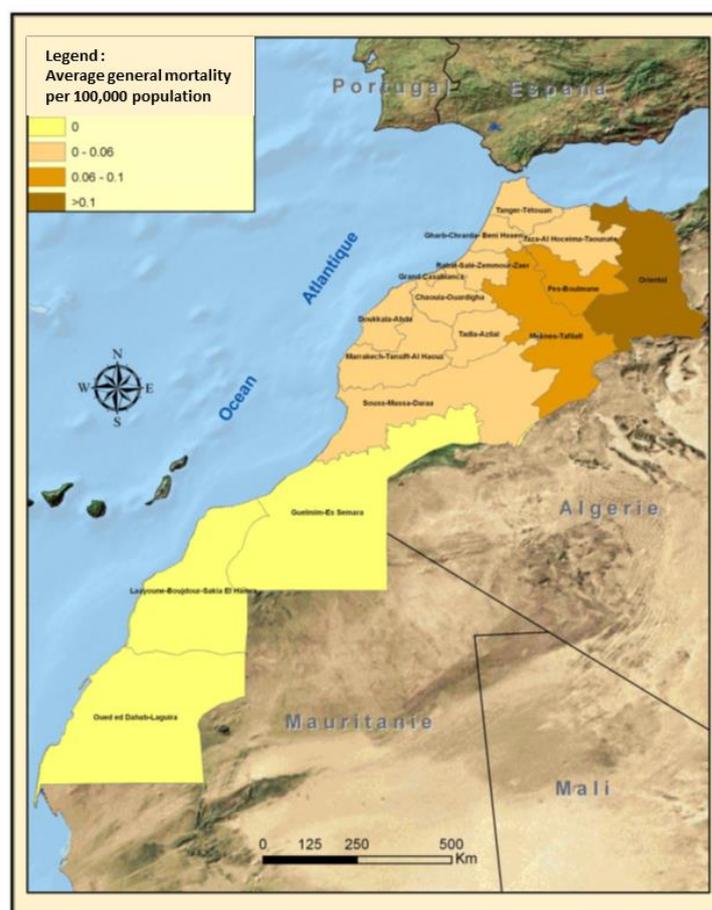


Fig. 2. Regional mapping of average mortalities due to CO poisoning during the period 1999-2013

The evolution of the annual mortality associated with CO poisoning at the national level for the period 1999-2013, which is represented by Figure 3, highlights, on the one hand, an annual variation in the mortality rate, and on the other hand, for the period as a whole, an increasing increase in mortality linked to the annual increasing increase in the reporting of deaths in all regions. The maximum rates are observed in 2012 and 2013, following the occurrence of 30 deaths in each of these years. The rate reaches 0.09 per 100,000 inhabitants, reflecting this growth in mortality over time [13].

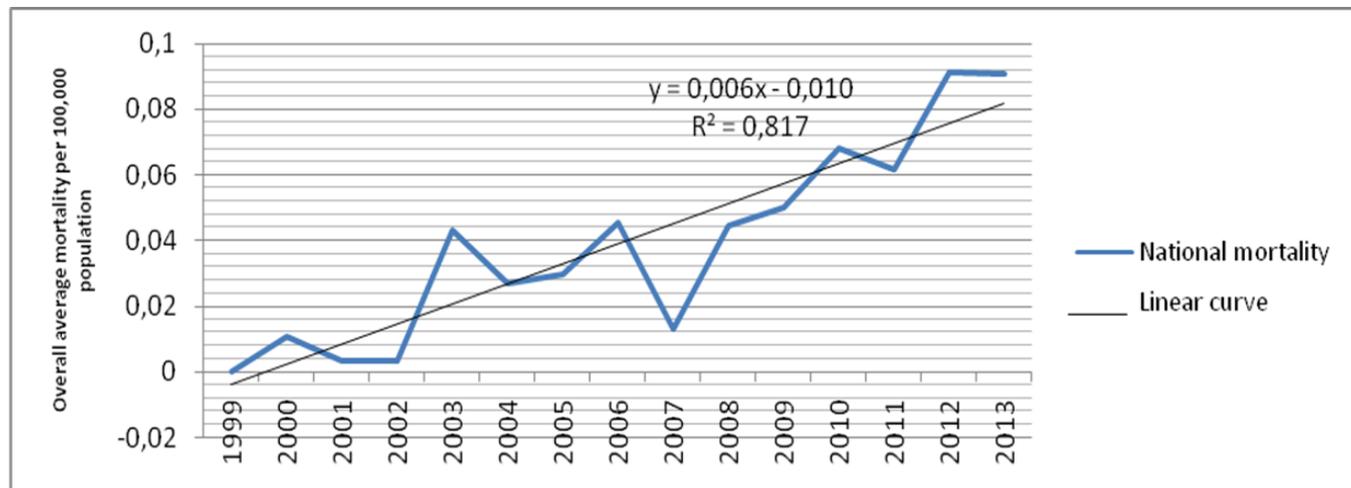


Fig. 3. Annual evolution of mortality due to CO poisoning at the national level [13]

### 3.3 EVOLUTION OF LETHALITY

The comparative analysis of the mapping and the average case fatality rates of the period 1999-2013, illustrated respectively by Figures 4 and 5, and the annual regional variations in the rates make it possible to subdivide the regions of Morocco into four groups:

- The southern regions of Morocco, namely Guelmim-Es Semara, Laayoune-Boujdour-Sakia El Hamra, and the region of Oued Ed Dahab-Laguira do not record any cases of death during the entire period studied, so the lethality is zero
- Regions with a lower than average case fatality (less than 1%): L'Oriental, Marrakech-Tensift-Al Haouz, Meknes-Tafilalt, Greater Casablanca, Tangier-Tetouan, Chaouia-Ouardigha and Tadra-Azilal. It is important to note that the annual distribution of lethality in each of these regions does not show a steady evolution
- Regions whose average lethality due to CO poisoning is higher (between 1% and 2%): Fez-Boulmane, Gharb-Chrarda-Beni Hssen, Rabat-Salé-Zemmour-Zaer, Doukkala-Abda, and Souss-Massa-Drâa. These case fatality values result from peaks recorded in specific years without any progression or regression over time
- The region of Taza-Al Hoceima-Taounate indicates a significantly high average lethality (7.685%). However, this value is unreliable in the sense that there is a very clear under-reporting of cases of poisoning in the region. Indeed, this average case fatality is influenced by rates of 66.67% in 2010 and 33.33% in 2011 recorded respectively following two deaths among only three cases of intoxication and one case among only three reported cases



Fig. 4. Regional cartographic representation of mean lethality rates due to CO poisoning during the period 1999-2013

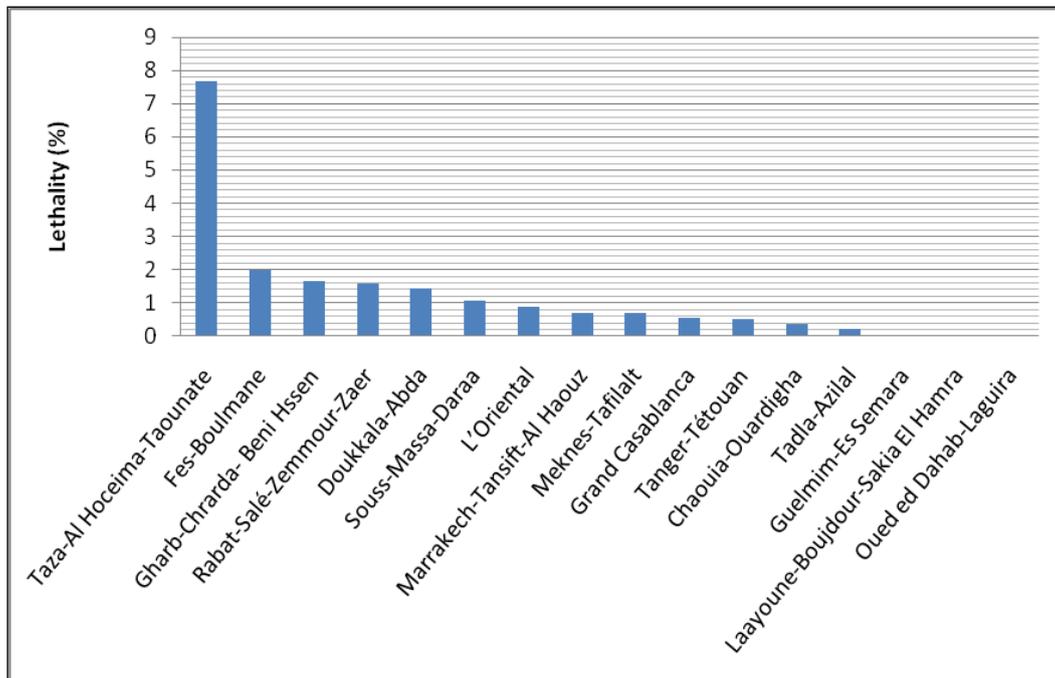


Fig. 5. Distribution of average rates of regional case fatalities due to CO poisoning over the period 1999-2013

On the other hand, considering the annual case fatality rate at the national level from 1999 to 2013, represented by Figure 6, we note that the evolution shows that the year 2003 holds the highest value (1.443%), followed by the year 2010 (1.235%) and finally the year 2013 (1.234%). Overall, there is an increasing increase in lethality. This is linked to the increase in the annual total of death reports in the different regions.

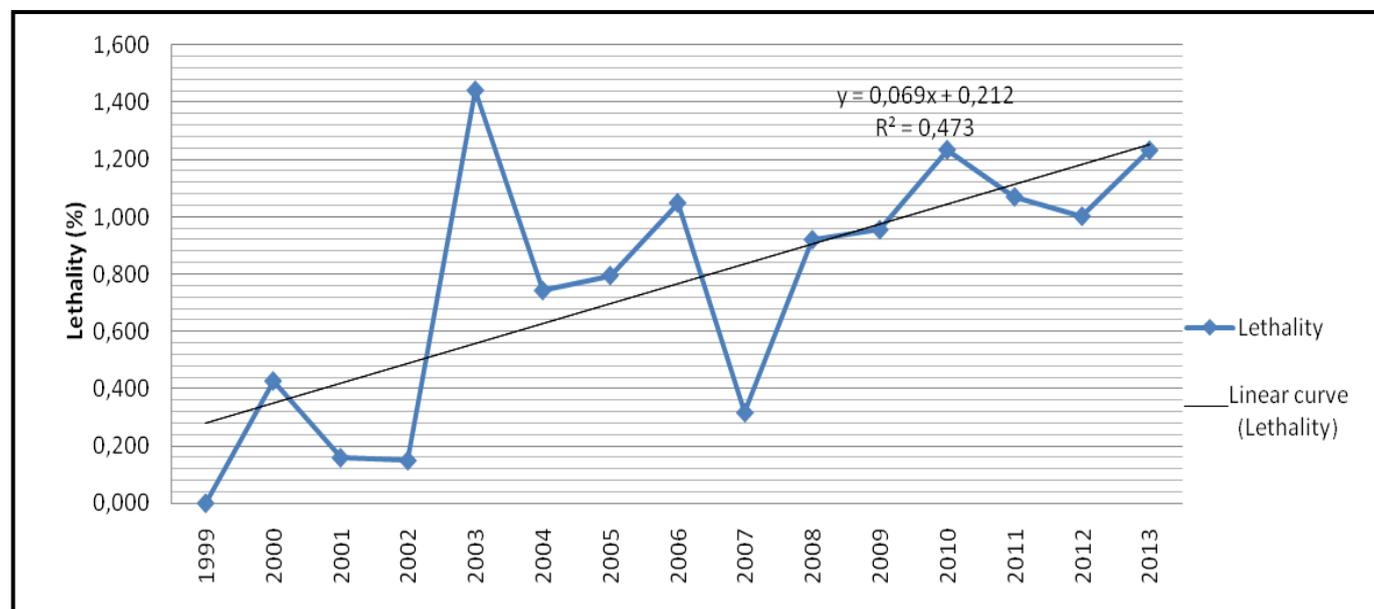


Fig. 6. Annual evolution of case fatality due to CO poisoning at the national level

#### 4 DISCUSSION

The results of the study of the evolution over time (over 15 years: from 1999 to 2013) and in the space of epidemiological indicators related to CO poisoning makes it possible to identify a certain amount of information specific to each indicator.

Thus, the evolution of incidence, as a dynamic indicator of morbidity, during the period 1999-2013 at the regional level is constantly increasing over time [12]. The highest incidence in terms of average concerns the region of Meknes-Tafilalt (with 0.112 per 1000 inhabitants). Also the incidence is significant in the regions of Tadla-Azilal, Fez-Boulmane, Tangier-Tetouan, and Oriental with average incidences of 0.087, 0.078, 0.078, and 0.075 per 1000 inhabitants respectively.

This distribution of incidence reflects a correlation between CO poisoning and the climatic peculiarity of these regions, which are characterized by colder autumn and winter seasons. However, we must not neglect the unpredictable nature of intoxication linked to the sociological behavior of populations. The most concrete example concerns the Greater Casablanca region, the most populous in Morocco. Indeed, it has significant fluctuations in incidence as a function of time. The impacts, therefore, show that the pathology is constantly increasing due to several factors, namely accidentality, climate, and the sociological peculiarities of the populations.

The study of the evolution of mortality, as a dynamic indicator of severity, highlights that, except for the southern regions (Laayoune-Boujdour-Sakia El Hamra, Guelmim-Es Semara, and Oued Ed Dahab-Laguira) which do not record any deaths, the annual retrospective assessment of the frequencies of deaths in the populations of the other regions reveals fluctuations in mortalities from one year to another.

At the national level, mortality is growing overall over time in line with the increase in death reports [13].

We can conclude from this that the evolution of mortality has a more or less random aspect at the regional level because of the accidental nature of the occurrence of deaths. On the other hand, at the national level, the increase in deaths over time leads to a continuous increase in mortality rates.

Regarding lethality, as for mortalities, and outside the southern regions, the evolution of CO poisoning at the regional level testifies to annual fluctuations in deaths among intoxicated patients. This is explained by their accidental and unpredictable appearance. At the national level, the evolution of lethality reveals overall growth over time-related to the increasing increase in cases of death.

It follows from the study of the evolution of these health indicators that the pathology records an increasing evolution over time, in terms of the frequency of poisonings and deaths generated, and therefore health impact. This results mainly from the accidental occurrence of these poisonings and their fatal course, but also certain regional and behavioral characteristics. Indeed, the impacts are conditioned by the autumn and winter temperatures specific to certain regions, while the annual regional fluctuations in mortalities and lethalties confirm the accidental nature of the occurrence of deaths due to CO poisoning regardless of regional characteristics.

## 5 CONCLUSION

Unintentional carbon monoxide poisoning persists every year despite preventive control efforts by Morocco's Poison Control and Toxicovigilance Center. These poisonings are the cause of hundreds of hospitalizations and many deaths, hence their cost in terms of public health and human lives. Thus, the information from the study of the spatial-temporary evolution of health indicators related to CO poisoning makes it possible to highlight another aspect of its severity at both regional and national levels. These epidemiological data contribute to a better understanding of the pathology and therefore to better frame its prevention and management of this scourge to improve the health of populations about these poisonings.

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