Fatal Poisonings: Autopsy-Based Study
Ölümcül Zehirlenmeler: Otopsi Temelli Çalışma

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ABSTRACT

Objective: Poisoning is an important public health problem. This study aimed to investigate the demographic characteristics, toxic agents causing death, and the cause of exposure in victims who died due to poisoning.

Methods: In this autopsy-based retrospective study, the demographic data, exposure to toxic substances, cause of death, and date and place of death of victims who died due to poisoning between January 2011 and December 2020 were recorded.

Results: A total of 90 fatal poisoning cases were investigated. The majority of the victims were male (n=69, 76.7%) with a mean age of 43.2±21.5 years. While 13 (14.4%) patients were younger than 18 years old, 14 (15.6%) were 65 years or older. The majority of deaths occurred at the scene (54.4%) and during the winter season (37.8%). While accidental exposure (41.1%) was the most common cause, suicide (31.1%) was the second. Carbon monoxide (CO) was the main toxic agent causing death, followed by the use of prescription drugs and illicit drugs.

Conclusion: CO is the most common cause of death, and the vast majority of victims were exposed by accident. It is important to educate the public and take the necessary precautions in reducing these deaths. Prescription drugs and illicit drugs were other common causes of death, respectively.

Keywords: Fatal, poisoning, autopsy

ÖZ

Amaç: Zehirlenmeler önemli bir halk sağlığı sorunudur. Bu çalışmada zehirlenme sonucu ölen mağdurların demografik özellikleri, ölüme neden olan toksik ajanlar ve maruziyet nedenlerinin araştırılması amaçlanmıştır.

Yöntemler: Otopsiye dayalı bu retrospektif çalışmada, Ocak 2011-Aralık 2020 tarihleri arasında zehirlenme nedeniyle ölen mağdurların demografik verileri, maruz kalınan toksik maddeler, ölüm nedenleri, ölüm tarihleri ve yerleri kaydedildi.

Bulgular: Toplam 90 ölümcül zehirlenme olgusu araştırıldı. Mağdurların çoğunluğu erkekti (n=69, %76,7) ve yaş ortalaması 43,2±21,5'ti. Hastaların 13'ü (%14,4) 18 yaşından küçükken, 14'ü (%15,6) 65 yaş ve üzerindeydi. Ölümlerin çoğu olay yerinde (%54,4) ve kış mevsiminde (%37,8) meydana geldi. Ölüme en sık kaza sonucu maruz kalma (%41,1) neden olurken, intihar (%31,1) ikinci sıradaydı. Ölüme neden olan başlıca toksik ajan karbonmonoksitti (CO), bunu reçeteli ilaç ve yasa dışı uyuşturucu kullanımı izledi.

Sonuç: CO en yaygın ölüm nedenidir ve kurbanların büyük çoğunluğu kaza sonucu maruz kalmıştır. Bu ölümlerin azaltılmasında halkın eğitilmesi ve gerekli önlemlerin alınması önemlidir. Reçeteli ilaçlar ve yasa dışı uyuşturucular sırasıyla diğer yaygın ölüm nedenleriydi.

Anahtar Sözcükler: Ölümcül, zehirlenme, otopsi

Introduction

Poisoning, one of the leading causes of emergency department presentations, is a public health problem that can cause significant morbidity and mortality worldwide (1-3). Deaths related to acute poisoning may occur due to accidents, suicides (intentional), and substance use disorders (4-6). The agents causing poisoning

vary depending on many factors such as geography, accessibility, socio-economic conditions, and cultural and religious influences (7). Detection of toxic agents that cause deadly poisoning is important to prevent poisoning-related deaths, take additional preventive measures, and provide effective care. Within this scope, this study aimed to identify the toxins that led to fatal poisoning in our region and to present the demographic characteristics of the patients. The results obtained from the study might be useful in preventing deaths caused by poisoning in our region.

Methods

In Turkey, poisoning cases are considered judicial cases. In poisoning-related deaths, a medicolegal autopsy is performed and a scan is made for possible toxins. This retrospective study was carried out by examining the post-mortem records of the cases that had medicolegal autopsy due to poisoning by the Forensic Medicine Institution of Fırat University between January 2011 and December 2020. Cases whose definite cause of death was poisoning as a result of corpse examination, autopsy, and toxicological and pathological examination were included in the study. All deaths due to poisoning occurring inside and outside of the hospital in the aforementioned period were included. Patients' age, gender, exposure to substances, autopsy findings, cause, date, and place of death were recorded. Toxicological test results at the time of admission to the hospital and in the forensic report were recorded. Alcohol, medications, illicit drug levels, blood, and urine samples were studied with ADVIA 1800 Chemistry System (Germany) and commercial kits in hospital admissions. Carboxyhemoglobin levels were measured using the Radiomater ABL AQT90 flex blood-gas analyzer (Denmark). Blood and urine samples for postmortem drugs and pesticides were purified with Solid Phase Extraction Method using OASIS HLB cartridges and the active substances were measured in liquid chromatography-mass spectrometry (LC-MS) and GC-MS (GC-MS) devices. Alcohol and volatile gases in biological fluids were analyzed by headspace-GC (HS-GC) technique. Corrosive substances were analyzed by wet methods such as acid-base methods and anion-cation analysis. Toxic agents were divided into seven groups: Carbonmonoxide (CO), prescription drugs, illicit drugs, alcohol, pesticides, volatile gases and corrosive materials. Since this study was retrospective, patient consent was not obtained. The study was conducted in accordance with the Helsinki Criteria. Ethics committee approval was obtained for the study (22.09.2021-3772).

Statistical Analysis

Statistical Package for the Social Sciences (SPSS 22, Chicago, IL, USA) was used for statistical analysis. The independent samples t-test was used to compare continuous variables while Pearson's χ2 test was used for categorical variables. Results were presented as numbers, percentages, mean, minimum (min), and maximum (max) values.

Results

A total of 90 fatal poisoning cases were included in this autopsy-based retrospective study. Most of the deaths due to poisoning were male (n=69, 76.7%) and the mean age was 43.2±21.5 years. While only one of the victims was a foreign national (Syrian), the majority of them were from Elazığ (n=61). Others were mostly from nearby provinces [Tunceli (n=9), Bingöl (n=4), Ankara (n=2), Adana (n=2), Muş (n=2), Erzurum (n=1), Erzincan (n=1), Van (n=1), Şırnak (n=1), Diyarbakır (n=1), Şanlıurfa (n=1), Osmaniye (n=1), Ordu (n=1), İstanbul (n=1)].

When the occupations of the deceased were examined, most of them were not working (13 children, 21 unemployed, 14 housewives). While 12 people were self-employed, 8 people were public employees. The occupations of the remaining 22 people could not be determined.

Most deaths occurred in winter (37.8%), followed by summer (22.2%), autumn (21.1%), and spring (18.9%), respectively. CO poisoning was the main cause of death during the winter months. The distribution of toxic agents causing death by seasons and years is shown in Figures 1 and 2.

While approximately half of the deaths (n=49, 54.4%) occurred at the pre-hospital crime scene, 9 (10%) were brought to the emergency department withcardiopulmonary arrest and died there. Additionally, 32 patients (35.6%) died in the service or intensive care unit.

While there was accidental exposure in 42.3% of the victims, 31.1% died due to suicide and 23.3% due to substance abuse. Three patients (3.3%) died due to adverse reactions related to medical applications. While the cause of death was anaphylaxis because of parenteral antibiotic use in two patients, it was neuroleptic malignant syndrome that developed due to antiparkinsonian drug use in one patient. The majority of deaths (80%) involved exposure to a single toxic agent.

The most common cause of death was CO poisoning (36.7%, n=33). While only one of these patients committed suicide, the others had accidental exposure. The mean carboxyhemoglobin saturation of the victims was 52.2±17.1% (min 12, max 82). Most of the CO poisonings were caused by coal stoves (n=17, 51.6%), followed by fire (n=5, 15.2%), natural gas (n=4, 12.1%), charcoal (n=3, 9.1%), and water well (n=2, 6.1%), respectively. In 2 patients, the cause could not be determined.

The use of prescription drugs (30%, n=27) was the second most common cause of death. Ten of these patients had multiple prescription drug intake, 10 had a single prescription drug intake, and seven had illicit drug and/or alcohol intake in combination with the medical drug. While most of the patients (55.6%) took drugs for suicidal purposes, 33.3% used them due to addiction and 11.1% used them due to medical purposes. Ten of the patients (37%) had a known history of psychiatric illness or substance abuse.

The third most common cause of death was illicit drugs (10%). All of the victims had a history of substance abuse.

Alcohol was detected in 8.9% of the deaths due to poisoning. Ethanol was detected in 5 victims. While only 1 took ethanol alone, 2 of them were accompanied by illicit drugs, 1 of them

methanol and 1 prescription drug use. Toxic agents detected in poisoning deaths are given in Table 1.

Considering the route of exposure to the agent, 43.3% were oral, 42.2% were inhalative, and 6.7% were parenteral exposures. In 5.6% of the cases, the route could not be identified. There was both oral and parenteral exposure in 1 case (1.1%).

There were 13 patients (14.4%) aged 18 years and younger, and most of them (n=9, 69.2%) had accidental exposure. Six of the victims died due to CO poisoning, 3 due to pesticide poisoning, 2 due to illicit drugs, 1 due to butane, and 1 due to medical applications.

Table 1. Toxic agents detected in poisoning deaths

Toxic agents	n (%)
Carbon monoxide	33 (36.7)
Prescription drugs	27 (30)
o Benzodiazepines	7 (7.8)
o Opioids	6 (6.7)
o Antidepressant drugs	6 (6.7)
• SSRI	4 (4.4)
• TCA	2 (2.2)
o Antipsychotic	5 (5.6)
o Beta blocker	4 (4.4)
o Antiepileptic	4 (4.4)
o NSAID	4 (4.4)
o Paracetamol	1 (1.1)
o Other drugs*	6 (6.7)
Illicit drugs	9 (10)
o Cannabinoid	6 (6.7)
o Amphetamine	5 (5.6)
Alcohol	8 (8.9)
o Ethanol	4 (4.4)
o Methanol	3 (3.3)
o Ethanol + methanol	1 (1.1)
Pesticides	8 (8.9)
o Organophosphates	3 (3.3)
• Dimethoate	2 (2.2)
• Chlorpyrifos	1 (1.1)
o Aluminum phosphide	2 (2.2)
o Cypermethrin	1 (1.1)
o Fenpyroximate	1 (1.1)
o Unknown	1 (1.1)
Volatile gases (butane, propane, toluene)	7 (7.8)
Corrosive material	5 (5.6)

NSAID: Non-steroidal anti-inflammatory drug, SSRI: Selective Serotonin Reuptake Inhibitor, TCA: Tricyclic antidepressant,
*Clopidogrel, colchicine, pramipexole, pregabalin, metformin

There were 14 patients (15.6%) aged 65 and over, and 11 (78.6%) of them had accidental exposure. While CO was the most common toxic agent in 9 patients, it was pesticides in 2 patients, prescription drugs in 2 patients, and exposure to corrosive substances in 1 patient.

Discussion

Poisoning, which is a serious problem throughout the world, continues to be an important health issue in Turkey. In this retrospective study, a total of 90 fatal poisoning cases that took place over a 10-year period in the province of Elazığ in eastern Turkey were examined. The socio-economic level of the region where the research was conducted was moderate. In our study, most of the victims were male (n=69, 76.7%) and their mean age was 43.2±21.5. In previous studies, similar to our study, the mortality rates were reported to be higher in males (8-11) and young people were more likely to be victims (2).

Previous studies showed that in most fatal poisonings, the victims were found dead at the scene (5,12). In our study, we found that 54.4% of the victims were found dead at the scene, and 10% were brought to the emergency department with cardiopulmonary arrest and died there. The most important factor in reducing these deaths was prevention (12). The remainder of the deaths occurred in the service or intensive care unit.

In a study examining poisoning cases in Turkey between 1923 and 2019, the most common causes of poisoning in Turkey were found to be by accident and for the purpose of suicide (13). In our study, we found that poisoning-related deaths mainly occurred as a result of accident (42.3%) and suicidal intake (31.1%). Victims aged 18 and under as well as victims aged 65 and over had a higher accidental exposure rate (69.2% and 78.6%, respectively).

In the current study, the most important toxic agent causing death was CO, followed by prescription drugs and illicit drugs. Toxic agents that cause deadly poisoning are affected by many factors and vary between countries and change over time. In a study examining fatal poisonings in South India between 2000 and 2006, it was reported that 92.9% of the victims were self-poisoned, and organophosphate compounds (68.7%) were the most common toxic agent causing death (3). In another study examining fatal poisonings that took place in Finland between 2004 and 2009, antidepressants and opioids were found to be the most common medicinal substances causing death (11). A study examining poisoning deaths in Brazil between 2009 and 2013 reported that 50.8% of deaths occurred due to unintentional intake; the main active ingredients were drugs (49.4%), followed by pesticides (29.9%) (8). Additionally, 76.1% of poisoning-related deaths involving 689 cases in northern Finland between 2007 and 2011 were unintentional exposure, and ethanol was the most common poisoning agent (12). In their study in which they analyzed the data of the American College of Medical Toxicology between 2010 and 2016, Friedman et al. (14) reported that 72.7% of fatal poisoning cases had suicidal exposure and most of the deaths (65.3%) were related to pharmaceutical agents.

In a few previous studies in Turkey, similar to our results, CO was shown to be the most common toxic agent causing fatal poisonings (9,10,15,16), whereas pesticides were the most common agents in one study (17). It was reported that almost all of the deaths caused by CO poisoning in Turkey occurred as a result of accident and most frequently in the winter months (9,10,15,16). While only one of the cases with CO poisoning in our study was due to intentional exposure, the remaining 32 cases were unintentional deaths from coal stoves, water heaters, fire, indoor charcoal use, and water wells. The use of coal stoves for heating in winter, fires, gas water heaters, and indoor barbecues are the main causes of CO poisoning (10,11,15,16). The use of CO sensors, appropriate ventilation, and training programs can help prevent CO poisonings (10,18).

The use prescription drugs (30%) was the second most common cause of death, and most of the patients (55.6%) had taken them for suicidal purposes. Drug-induced poisoning is a common problem worldwide, and the active ingredients vary according to the regions (19). It has been reported that 1% of emergency service admissions and 0.2% of forensic autopsies are due to medical drugs (20). In their study, in which they examined cases that presented to the emergency department and resulted in death due to overdose, Friedman et al. (14) reported that non-opioid analgesics were the main agents, followed by opioids, cardiovascular drugs, sedatives, antipsychotics, antidepressants, and sympathomimetics. On the other hand, Lapatto-Reiniluoto et al. (11) reported that antidepressants and opioids were the most common medicinal substances leading to death in Finland. The main prescription drugs responsible for death in our study were benzodiazepines, opiates, and antidepressants. Similar to our study, Battal et al. (16) reported that the most common prescription drug causing death was benzodiazepines, followed by antidepressants and analgesics. Birincioglu et al. (10)
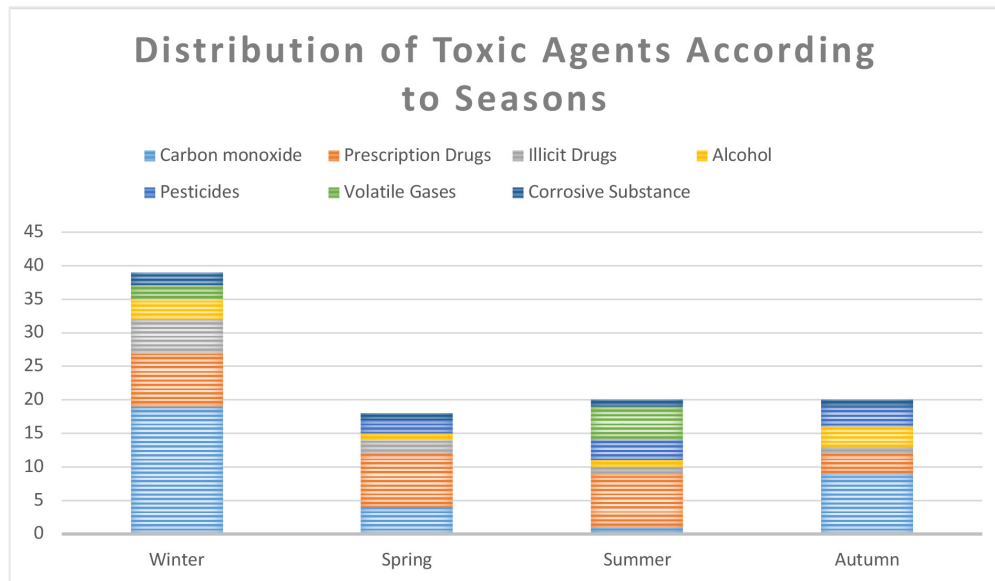

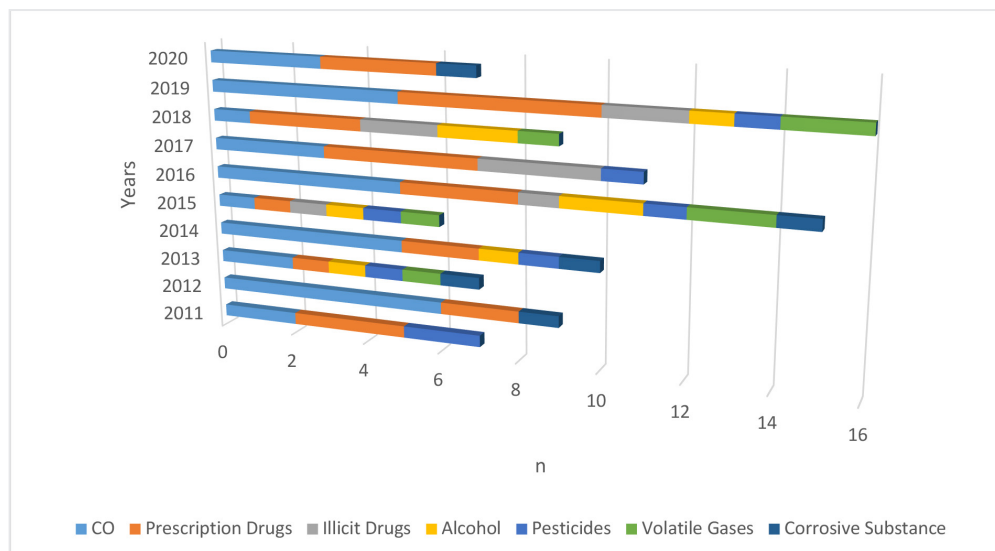**Figure 1.** Distribution of toxin agents by seasons

Figure 2. Distribution of toxic agents by years

also reported that fatal drug poisonings mainly occur due to antidepressants and benzodiazepines.

The use of illicit drugs was the third most common cause of death. Although deaths due to substance use disorder are generally thought to occur as a result of accident, the actual intent is unclear (5). All of the victims in our study had a history of substance abuse.

Pesticides were responsible for 8.9% (n=8) of the deaths and most of them were exposed by accident (n=5). Since pesticides are widely used in agriculture, it is one of the common causes of chemical poisoning (3,9). Pesticides are associated with high rates of poisoning, both intentional and accidental, due to reasons such as being applied without adequate protection and being cheap and easy to find (9,10).

Alcohol was detected in 8.9% of the victims. Four of them had drunk ethyl alcohol, 3 had drunk methyl alcohol, and one had drunk both ethyl and methyl alcohol. Alcohol-related death rates vary between countries. In studies conducted in Turkey, rates ranged from 7.4% to 18.4% (9,10,16,19). In our study, 2 of the 4 patients who died due to methyl alcohol had drunk fake or illegally produced alcohol and one had drunk cologne. The substance could not be detected in 1 case. Fake or illegally produced alcohol consumption is an important social problem and it is important to inform society about the dangers of fake alcohol consumption to be able to prevent these deaths. Ethyl alcohol alone caused death in only 1 of the 5 victims. In the others, prescription drugs, illicit drugs or methyl alcohol were taken together with ethyl alcohol.

Volatile gases (butane, toluene, propane) were responsible for 7.8% of deaths and all were intentional exposures. Four of those who died were drug addicts. Volatile substances act quickly, have pleasant and slightly intoxicating effects. It is widely used in society because it is cheap and easy to find, and it continues to be an important public health problem (21). Volatile substance abuse is associated with an increased risk of sudden death, and asphyxia, vagal inhibition, cardiac dysrhythmia, and respiratory depression that can be mortal (22).

Exposure to corrosive substances may be accidental or suicidal. After ingestion, it causes significant damage to other systems, especially the gastrointestinal tract, and may even cause death (23,24). In our study, while 4 of the deaths due to corrosive substances were intentional, 1 was accidental and they were responsible for 5.6% of the deaths.

Study Limitations

Since our study is a retrospective study, missing data may have been entered.

Conclusion

In our study, deaths due to poisoning mostly occurred in males, and the most common causes of exposure were by accident and for the purpose of suicide. CO was the most common fatal toxin, and almost all victims were exposed by accident, and exposures occurred mostly during the winter season. It is important to provide trainings and take necessary precautions to reduce these deaths. It was noteworthy that some medications were also used for suicidal purposes.

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