Panorama *of* Emergency Medicine

Vol. 4 No. 1 2026 Narrative Review

# Acute poisoning management in MENA low- and middle-income countries: clinical practices, toxicological resources, and healthcare challenges – A Narrative Review

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## ABSTRACT

### Background

Acute poisoning is a major global cause of emergency presentation and preventable mortality, with substantial burden in low- and middle-income countries (LMICs). Objective: This narrative review examines the clinical management, analytical Toxicology and challenges of acute poisoning in Middle East and North Africa (MENA) LMICs.

### Methods

A structured literature search of PubMed/MEDLINE and Google Scholar (January 2006–December 2025) was conducted for studies on acute poisoning in Algeria, Egypt, Libya, Morocco, Tunisia, Jordan, and Lebanon. Studies were included if they involved human subjects with acute poisoning and addressed epidemiological or management-related outcomes. The final set included 100 academic articles and 2 additional sources (medical theses).

### Results

Published evidence on clinical management in the MENA LMIC is limited. The review reveals a dual toxicological burden where rising pharmaceutical overdoses coexist with persistent agricultural and environmental threats. A major message is the significant gap between international guidelines and local practice, evidenced by a high reliance on gastric lavage and the underutilization of activated charcoal. Management is severely hindered by systemic infrastructure deficits, including chronic antidote shortages, limited analytical toxicology, and restricted access to advanced therapies like ECMO. These challenges frequently result in non-standardized, ad hoc patient care.

### Conclusions

Improving outcomes requires a transition from fragmented management to structured national responses. Key priorities include developing context-specific clinical guidelines, establishing regionalized expert centers, and implementing robust national antidote distribution systems.

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Submitted: 27 June 2026
Revised: 17 August 2026
Accepted: 18 August 2026


Published by New Health Concept
panoramaoem.cloud



**How to cite this paper?** Jeddi C, Thabet H, Ebn Ebrahim Y, Chaouali N, Abidi S, Mrad A. Acute poisoning management in MENA low- and middle-income countries: clinical practices, toxicological resources, and healthcare challenges – a narrative review. Panorama of Emergency Medicine. 2026,4(1) **https://doi.org/10.26738/poem.v4i1.27**

## INTRODUCTION

Acute poisoning is a common and serious cause for emergency medical presentations worldwide, posing significant diagnostic and therapeutic challenges. It results from exposure to diverse toxic substances, including medications, pesticides, and household or environmental chemicals. Clinical manifestations present with a broad clinical spectrum, from mild symptoms to life-threatening organ failure and death. Outcomes largely depend on the agent, dose, route of exposure, and timeliness of care. According to the World Health Organization (WHO), unintentional poisoning caused over 100,000 deaths globally in 2016, underscoring its role in preventable mortality. This constitutes a substantial burden on healthcare systems, particularly in resource-limited settings [1, 2].

In the Middle East and North Africa (MENA) region, especially in low- and middle-income countries (LMICs), acute poisoning remains a major public health concern and a frequent reason for emergency consultation. Patterns of poisoning vary across the region, with pesticide exposure, pharmaceutical overdoses, and carbon monoxide poisoning among the leading causes, alongside occasional large-scale toxic outbreaks [3–8]. Differences in healthcare infrastructure, antidote availability, and access to specialized toxicology services in these countries further influence patient outcomes [9].

This narrative review aims to describe general and specific management approaches across prehospital care, emergency departments, and intensive care settings in the MENA region LMICs. Emphasis is placed on region-specific challenges, including resource limitations, in order to provide a practical framework to support clinical decision-making and potentially improve patient prognosis.

## METHODS

A structured narrative review focused on the epidemiology and management of acute poisoning in the MENA region LMICs. This approach was considered the most appropriate given the heterogeneity of the available studies and the limited availability of regional data, which precluded meaningful quantitative synthesis. A targeted literature search was performed in PubMed/MEDLINE and Google Scholar for studies published between January 2006 and December 2025. This 20-year period was selected to capture the most influential studies and relevant literature in the field while ensuring the review reflects current knowledge and practice. The search used combinations of the following keywords: “poisoning”, “intoxication”, “acute poisoning”, “epidemiology,” “management,” “treatment,” “antidote”, “emergency care”, “analysis”, analytical toxicology”, “screening”, “Gas Chromatography-Mass Spectrometry (GC-MS)”, “Liquid chromatography-tandem mass spectrometry (LC-MS/MS)”, “Atomic absorption spectroscopy (AAS)”, “extracorporeal life support”, “extracorporeal membrane oxygenation (ECMO)”, and terms related to the MENA region LMICs. A predefined search strategy was developed and adapted to the syntax and indexing terms of each electronic database. No language restrictions were applied during the literature search.

This review was designed to focus on the countries for which the most relevant, recent, and substantial body of published evidence was available regarding the topic under investigation. While other MENA region LMICs were considered, the available literature from these settings was either very limited, outdated, or insufficient to support a meaningful analysis within the scope of the review. Therefore, we prioritized countries with a larger and more recent evidence base to ensure a comprehensive and informative synthesis of the available data.

Studies were included if they involved human subjects with acute poisoning, were conducted in MENA region LMICs (Algeria, Egypt, Libya, Morocco, Tunisia, Jordan, and Lebanon), and reported epidemiological or management data. The literature search identified 654 records from PubMed/MEDLINE, ScienceDirect, and additional sources, including manual reference screening. After title and abstract screening, 201 articles were retained for full-text assessment. Studies were excluded for not meeting the predefined eligibility criteria, primarily due to irrelevant scope, non-human studies, lack of epidemiological or management data, or non-eligible publication types.A total of 16 duplicate records were removed using Zotero and manual verification. Ultimately, 112 studies (110 journal articles and 2 academic theses) were included in the narrative review **(Figure 1)**

Data extracted included study characteristics, population demographics, type of toxic agents, exposure patterns, outcomes, and management strategies including gastrointestinal decontamination, antidotal therapy, extracorporeal treatments, and toxicological analytical methods. Due to heterogeneity among studies, findings were synthesized narratively, focusing on major toxic agents and clinical management. Additional relevant studies were identified by manually screening the reference lists of the included articles, along with relevant gray literature and reference texts including medical theses, reports and guidelines from international organizations, as well as standard toxicology textbooks. Zotero software was used for reference management. Ethical approval was not required, as no human subjects were involved.

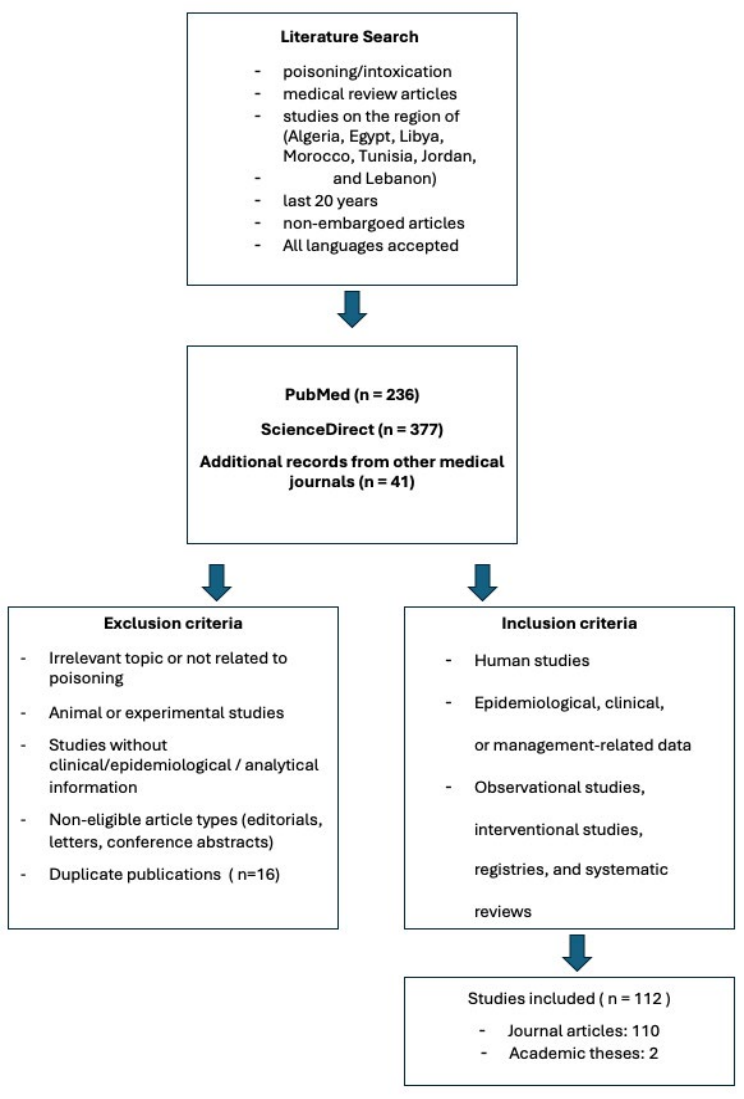


**FIGURE 1 - Study Selection Flow Diagram.**

## RESULTS

### Epidemiological findings

Poisoning in the MENA region reflects a dual pattern, involving both pharmaceutical overdoses and environmental or agricultural exposures [3–8]. Lebanese data indicate acetaminophen as a major toxicological agent, accounting for 10.1% of poison center telephone consultations, alongside a high prevalence of intentional self-poisoning among adolescents, reaching 87.8% of adolescent poisoning cases. [10, 11]. Egypt and Jordan both face substantial burdens from organophosphate and carbamate pesticides, with additional burdens of aluminum phosphide and opioid toxicity reported in Egypt. While in Jordan, specific pediatric risks from mushroom and Datura poisoning are reported. [4, 12–16]. In the Maghreb region, pharmaceutical poisoning represents the most common type of intoxication in Tunisia , accounting for approximately 72% of all reported poisoning cases. Among these, anxiolytic agents are implicated in 31% of cases , while analgesics account for 22% [6].

In addition, Tunisia and Morocco, share high frequencies of methanol, chloralose, and paraphenylenediamine (PPD) poisoning, as well as environmental threats from poisonous plants (such as Atractylis gummifera) and life-threatening scorpion envenomation [17–22]. Finally, in Libya, methanol poisoning and general pediatric cases are among the most frequently documented emergencies. Management in all six nations relies heavily on supportive care and guidance from poison information centers [8, 23, 24].

The main epidemiological patterns and management strategies identified across the included studies are summarized in Table 1.

 

**TABLE 1 - Patterns of acute poisoning in MENA region LMICs**

| *Region / Country* | First author; year | Specific public health context | Antidote administration | Gastric decontamination | | Other treatments /comments |
|---|---|---|---|---|---|---|
| | | | | Activated charcoal (AC) | Gastric lavage | |
| *Tunisia* | Nasri et al. 2023 [17] | Chloralose poisoning | - | 11.3% | 71.1% | MV 43.3% |
| | Kilani et al.2025 [25] | Cannabis poisoning in children (CR) | | | | Symptomatic treatment, MV |
| | Madhbouh et al.2024 [26] | Acute carbamazepine poisoning | - | 3% | 0% | Supportive (MV 10.4% and seizure control), 31% antiemetics. repeated doses of activated charcoal were more effective than a single dose |
| | Araoud et al.2025 [27] | Pesticide poisoning | 72% Atropine | - | 36% | MV 30% |
| | Khelifa et al. 2025 [7] | CO poisoning | 100% Oxygen therapy / 10.6% HBO | - | - | - |
| | Kaaniche et al. 2025 [28] | Drug poisoning | Done | Done | Done | MV, vascular filling, catecholamines, anticonvulsants/ psychiatric evaluation |
| | Hamdaoui et al 2024 [29] | Scorpion envenomation | Anti scorpion serum | - | - | Oxygen therapy 6.7%, ionic correction 5%, glycemic correction 16.7%, dobutamine 6.7%, MV (1 case) |
| | Bel haj et al. 2024 [30] | Subarachnoid hemorrhage in ecstasy abuse (CR) | - | - | - | Head scan, neurosurgery, conservative treatment, endovascular embolization |
| | Ketata et al.2022 [18] | Methanol poisoning | - | - | - | 20% MV, 70.7% Oxygen therapy , hydration with saline, folic acid 5% |
| *Morocco* | Zniber et al.2025 [19] | Methanol poisoning | Unavailable | - | - | Hemodialysis |
| | Samali et al 2025 [20] | Alpha chloralose poisoning | | 22.6% | 52.6% | Endotracheal intubation 39.6%, Benzodiazepine 54% |
| | Oulmaati et al.2017 [21] | Poisoning by poisonous plant | - | - | - | Treatment is symptomatic and etiological |
| | Elmourid et al.2023 [31] | Scorpion stings / envenomation | Serotherapy | | | Painkillers/ prazosin /antihistamine / phenobarbital sodium/ anxiolytics/ antiemetics/ cardiac analeptics |
| | Derkaoui et al.2011 [22] | PPD poisoning | | - | 100% | Symptomatic treatment, MV, fluids, hemodialysis/ diuretic /alkalinization |
| | Azekour et al.2019 [32] | Pharmaceutical Overdose | - | - | - | Symptomatic treatment 47.8% |
| *Libya* | Zubaeda et al.2020 [23] | Poisoning cases in emergency department | Flumazenil 8.9% | | 84% | Antiemetics 89.5%, fluids, H2 receptor blocker 14.8% |
| | Rostrup et al.2016 [8] | Methanol poisoning | Fomepizole Ethanol | - | - | Sodium bicarbonate |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Libya* | Alaqeli et al.2023 [24] | Poisoning in children | Only Atropine was needed, but no case received an antidote due to the lack of atropine. | charcoal 0% | 107 cases out of 232 | |
| *Algeria* | Yamoun et al.2024 [33] | Acute poisoning | oxygen therapy (the only antidote used) for CO poisoning | 7% | 97% | Symptomatic treatment (MV 43%) |
| *Egypt* | Sayed et al.2024 [12] | Cardiovascular effect in acute opioid toxicity | - | - | - | The need for early cardiac evaluation in opioid poisoning is essential to predict outcomes and guide treatment. |
| | Sayed et al.2024 [34] | Acute poisoning in children | Done | Done | Done | Observation with supportive measures, 10.3% admitted to ICU |
| | Khayal et al.2024 [4] | Acute poisoning | Done | Done | Done | Conservative treatment, elimination enhancement as hemodialysis. |
| | El sarnagawy et al.2025 [35] | Pattern and impact of antidotal administration | Key antidote: atropine, pralidoxime, NAC, naloxone | - | - | Early antidote administration improves outcome<br>Supportive measures: sodium bicarbonate, folic acid, hyperbaric oxygen |
| | Abdel Baseer et al.2021 [13] | Acute OPP in children | Atropine<br>Pralidoxime | - | - | MV 13% |
| | Deraz et al.2022 [14] | Acute aluminum phosphide poisoning | No specific antidote | - | Avoid water gastric lavage (oil based only) | Supportive care and prevention of complications |
| *Lebanon* | El Zahran et al. 2021 [10] | Toxicological exposures among pediatric patients | NAC 15.3% | 2.9% | 2.4% | - |
| | Hitti et al.2020 [11] | Toxicological exposures reported to a telephonic consultation | Oral NAC (34% of acetaminophen poisonings)<br>- glucagon<br>- naloxone -<br>Vitamine K – snake antivenom | 9.9% | | Symptomatic and supportive treatment |
| | El Zahran et al. 2018 [36] | Snakebites | Polyvalent antivenom (37.5%) | - | - | 100% (intravenous fluids, antihistamine, hydrocortisone) |
| | Kadi et al.2025 [37] | Management of venomous bites and scorpion stings | Antivenom | - | - | Lack of standardized national protocols<br>Antivenom use is inconsistent and dependent on availability<br>Frequent misuse of antibiotics as first-line therapy |
| *Jordan* | Shotar et al.2012 [15] | Mushroom poisoning (CR) | | | | |
| | Alzayadneh et al.2024 [38] | Pediatric poisoning | - | - | - | Management guided by Poison Information Center; mainly supportive care, triage, and hospital referral |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Jordan* | Albals et al.2020 [39] | Nonpharma ceutical acute poisoning (poison call center) | - | - | - | Management mainly by poison center guiding home care or hospital referral; reduced admissions and ambulance use |
| | Abubaker et al.2022 [40] | Snakebites | Vins Snake venom antitoxin (Bio snake) | | | Ineffective antivenom (non-matching species) |
| | Zuhair et al.2017 [41] | Scorpion stings | Scorpion -specific antivenom (10 cases) | | | Supportive hospital care |
| | Tarawneh et al.2024 [16] | Datura pediatric poisoning | No antidote | - | - | Supportive care and symptomatic treatments |

**AC:** Activated charcoal; **CO:** Carbon Monoxide; **CR:** Case report; **HBO:** Hyperbaric oxygen; **ICU:** Intensive Care Unit; **MV:** Mechanical ventilation; **NAC :** N- acetyl cysteine , **OPP:** Organophosphorus Pesticides; **PPD:** Paraphenylene

### Patterns of general decontamination strategies including activated charcoal and lavage reported in the MENA region LMICs

Digestive decontamination practices vary considerably across the countries reviewed.

Gastric lavage remains frequently practiced in several North African countries despite international recommendations restricting its use, whereas its utilization appears limited in Lebanon [10, 22, 23, 42].

Activated charcoal is reported less frequently across the region. Libya data documents its administration in all pediatric poisoning cases, while Egypt results describe it as part of routine management for acute poisonings [4, 24]. In Lebanon and Tunisia, use is more selective, occurring in approximately 10% of cases or specifically for certain toxins like chloralose and carbamazepine poisonings [10, 17]. In Morocco, AC is used for chloralose (up to 61.7%), however, its use is often limited due to unavailability in some hospitals [20, 22].

Table 2 summarizes the reported decontamination practices employed in the management of acute poisoning across the MENA region LMICs.

**TABLE 2 - Reported Decontamination Practices in the Management of Acute Poisoning Across the MENA region LMICs**

| Country | Gastric Lavage (GL) Status | Activated Charcoal (AC) Use | Key Challenges & Notes |
|---|---|---|---|
| *Tunisia* | Utilized in diverse cases (e.g., 71% for chloralose) [17] | Selective (~10%); used for chloralose and carbamazepine [26] | AC is well-tolerated (89%) when guidelines are followed [43] |
| *Morocco* | Widely used; reaches 100% for PPD poisonings [22] | Used for chloralose (61.7%); limited by hospital availability [20] | Persistence of GL and delayed procedures noted despite guidelines |
| *Libya* | Common (84% of general cases) [23] | Routine in pediatric poisoning cases [24] | High reliance on GL persists across facilities |
| *Algeria* | High reported use (97%) [33] | Limited utilization (7%) [33] | Reflects broader North African trends of persistent GL use |
| *Egypt* | Specialized oil-based technique for aluminum phosphide [14] | Part of routine management for acute poisonings [4] | Water-based GL is contraindicated for specific agricultural toxins |
| *Lebanon* | Uncommon (~2% utilization) [10] | Selective (~10% of cases) [10] | Significant shift away from invasive decontamination compared to neighbors |
| *Jordan* | Centrally guided by the National Poison Information Center [38] | Guided by National Poison Information Center triage and telephone consultation [38] | Management is standardized through centralized expert advice |

**AC:** activated charcoal; **GL:** gastric lavage; **PPD:** Paraphenylenediamine

### Reported Antidotes used in management of acute poisoning across the MENA region LMICs

Across the studied MENA region LMICs, antidote availability is marked by significant regional and institutional disparities. While fundamental agents like atropine and N-acetylcysteine are generally accessible in countries such as Tunisia, Egypt, and Morocco, specialized treatments like fomepizole, digitalis antitoxins, and specific chelators are frequently unavailable or limited by high procurement costs and short shelf lives [6, 18, 27, 35, 44, 45]. Libya and Algeria healthcare systems struggle with acute shortages and the absence of standardized national guidelines, which forces clinicians to manage life-threatening poisonings on an ad hoc basis [8, 24, 46–48].

Furthermore, access to antidotes is heavily tied to hospital size and location. In Morocco and Lebanon, smaller and medium-sized facilities often lack the vital stocks which can be found in larger teaching hospitals [44, 49]. The situation is further complicated by the use of ineffective or imported antivenoms in Jordan and Lebanon, as well as a significant lack of comprehensive epidemiological data due to widespread underreporting [36, 37, 40].

A summary of reported practices regarding country-specific antidote utilization and barriers to optimal poisoning management in the MENA region LMICs are illustrated in Table 3.

**TABLE 3 - Availability and Limitations of Essential Antidotes and Clinical Management reported in the MENA region LMICs**

| Country | Available Antidotes | Unavailable or Limited Antidotes | Key Challenges & Notes |
|---|---|---|---|
| *Tunisia* | N-acetylcysteine, atropine, flumazenil, naloxone, pralidoxime, and antivenoms (scorpion/viper) [6,27] | Fomepizole [18] | Clinicians rely on intravenous ethanol for methanol poisoning [18] |
| *Morocco* | ~90.5% of essential antidotes are available in at least some facilities [44] | Flumazenil, glucagon, and digoxin-specific antibodies (frequently missing in smaller facilities) [44] | Availability is strongly tied to hospital size. Challenges include budgetary constraints and short product shelf lives |
| *Libya* | Atropine is often the only specific antidote available [24] | Oximes, fresh frozen plasma, ethanol, and fomepizole [8,24,46] | Supplies are often insufficient or administered with incorrect timing/dosages. Cases are managed on an ad hoc basis without standardized guidelines [46] |
| *Algeria* | Atropine [47,48] | Fomepizole, digitalis antitoxins, specific chelators, sodium calcium edetate, dexrazoxane, and succimer [47,48] | Many essential antidotes are either completely unavailable or present in less than 20% of hospitals. Shortages are linked to a lack of official stock guidelines and training [47,48] |
| *Egypt* | Atropine, oximes, and locally produced polyvalent antivenoms [50,51] | Fomepizole and digibind. No specific antidote exists for aluminum phosphide [14,35,45] | Approximately 93% of patients are managed without specific antidotes. Access to specialized agents is restricted by high costs and short storage lifespans [52] |
| *Lebanon* | N-acetylcysteine [10] | No surveyed facility carries the full range of 35 life-saving medications [49] | Stocks are suboptimal and vary by institution type (teaching vs. non-teaching) [49]. Antivenom is often imported due to a lack of local production [36,37] Note: Limited standardized reporting system regarding antidote stocks rather than complete absence in all facilities could explain the discrepancy in Lebanon's antidote availability. |
| *Jordan* | Scorpion antivenom (limited use) and African-snake-based antivenom [40,41] | Specific Datura antidote [16] | The available snake antivenom is clinically ineffective against Jordanian vipers. There is a significant gap in data due to widespread underreporting [40] |

### Extracorporeal therapy

Extracorporeal treatments are reported in Tunisia, Morocco, Libya, Egypt, and Algeria, with hemodialysis being the most frequently described modality. Across the included studies, severe methanol poisoning is the principal indication for extracorporeal therapy. In Tunisia, hemodialysis is performed in 69% of patients with methanol poisoning and achieved a mean reduction in serum methanol concentration of 79.4%, with resolution of visual impairment reported in several survivors [53]. During the 2013 methanol outbreak in Libya, 31.8% of patients underwent early hemodialysis, which was used in cases presenting with severe metabolic acidosis [54]. In Egypt, hemodialysis is consistently described as a key therapeutic intervention for severe methanol toxicity and was available in several major poison treatment centers, although its use represented a small proportion of all poisoning cases, ranging from 0.05% to 0.1% at Ain Shams University Hospitals to 1.48% at Zagazig University [4,45,52,55,56]. In Morocco, hemodialysis was utilized not only for methanol poisoning but also for poisonings involving lithium, glycols, and metformin [57]. Algerian studies identified extracorporeal therapy as one of the therapeutic approaches to acute poisoning, including selected cases of heavy-metal poisoning, although reported utilization rates were low, ranging from 0.2% of poisoning cases in a university hospital cohort to recommendations in 1.6% of poison center consultations [33, 48, 58]. Exchange transfusion was additionally reported in Morocco for the management of severe methemoglobinemia and toxic hemolysis [57].

### Analytical toxicology

The technical infrastructure for analytical toxicology across North Africa varies significantly, reflecting diverse organizational models and resource allocations.

Starting with the westernmost framework, Algeria's system is centralized around the National Toxicology Center / Poison Control Center (NTC/PCC), which coordinates regulatory and toxicovigilance activities with support from specialized departments within University Hospital Centers (CHU) [59]. Analytically, routine screening for heavy metals (lead, mercury) is performed via Atomic Absorption Spectroscopy (AAS) and ICP-MS [60–62]. Initial drug screening relies on immunoenzymatic techniques, confirmed by GC-MS [63]. For advanced investigations, including psychotropic substances and drugs of abuse, GC-MS and HPLC-DAD platforms are utilized. While co-oximetry remains the standard for carbon monoxide poisoning [62], spectrophotometric techniques are still maintained for specific drugs like salicylates in resource-limited rural facilities [64].

In contrast to this setup, neighboring Morocco operates a highly standardized and centralized system anchored by the Moroccan Poison Control and Pharmacovigilance Center (CAPM) [65–67], alongside the National Institute of Hygiene (INH) and academic hospitals (Fes and Casablanca CHUs). GC-MS is routinely used for detecting drugs [65] and pesticides [68,69], while LC-MS/MS stands as the gold standard for broad- spectrum screening (simultaneously detecting 27 benzodiazepines, 17 neuroleptics, 14 antidepressants, 9 illicit drugs, and 6 pesticides) [70]. Lead poisoning cases are confirmed via AAS [71], and addictology uses rapid immunochromatographic tests followed by LC-MS/MS confirmation [72].

Tunisia utilizes an integrated network that ensures national coverage through synergy between emergency care and specialized laboratories, notably the Mahmoud Yaacoub Emergency Medical Center (MYEMC) and the National Pharmacovigilance Center (CNPV). The MYEMC multi-purpose laboratory uses GC-MS and LC-MS/MS for forensic and clinical drug analysis [73,74]. Metal analysis in biological [75] and environmental [76] matrices is performed using Graphite Furnace Atomic Absorption Spectrometry (GFAAS). Drugs of abuse are screened via enzyme immunoassays and confirmed through liquid and/or gas chromatography-mass spectrometry [77–79]. Alcohols are determined either directly via alcohol dehydrogenase enzymatic techniques or after Cordebard extraction [80,81].

Further east, Egypt boasts one of the most extensive toxicology networks in the region, driven by modernization efforts from the Egyptian Drug Authority (EDA). This network is structured around forensic medicine, environmental surveillance (via the QCAP laboratory), and clinical toxicology laboratories at Cairo Universities [82]. analytical arsenal has shifted toward high-sensitivity methods, with GC-MS and LC-MS/MS becoming the gold standards [83] for detecting synthetic drugs [84] and pesticide residues [85]. Specifically, LC-MS/MS with electrospray ionization is widely employed for detecting compounds in biological fluids, ranging from oral antidiabetics, antiepileptics [86], and immunosuppressors [87] to toxic plants [88]. For rapid urinary screening and routine monitoring, enzymatic and fluorometric immunochemical techniques (FPIA) remain prevalent, while AAS is essential for industrial heavy metal monitoring.

## DISCUSSION

### Patterns of acute poisoning in the MENA region LMICs

The coexistence of pharmaceutical overdoses and environmental or agricultural poisonings observed across the region illustrates the complex toxicological landscape of the MENA region LMICs. While pharmaceutical poisoning may reflect growing medication availability and self-poisoning behaviors [89], the continued prominence of pesticide

poisonings highlights ongoing occupational and domestic exposure risks. The consistent reporting of pediatric poisonings further emphasizes the need for improved household safety measures, poison prevention programs, and regulation of hazardous substances [90].

Although the World Health Organization suggests one poison control center for every 5 to 10 million people [91], existing services in these countries are often limited in capacity or underutilized. Limited accessibility, inadequate resources, and lack of awareness of poison center services may delay or preclude consultation with toxicology experts, contributing to suboptimal, non-standardized management and highlighting critical gaps in poisoning care systems [1, 92].

### Decontamination Strategies

Activated charcoal administration remains a cornerstone for management of acute poisoning. The Toxicology Recommendations Collaborative Workgroup recently expanded the recommended time frame for single-dose activated charcoal administration beyond the traditional one-hour window up to six hours post ingestion for selected poisons, depending on their physicochemical properties and pharmaceutical formulation. Furthermore, administration beyond six hours is appropriate when prolonged absorption is suspected, such as in cases involving pharmacobezoars or massive drug burden [93]. In addition, the tolerance of activated charcoal administration should be carefully monitored in patients. A recent Tunisian study demonstrated that, when administered in accordance with established guidelines, activated charcoal was well tolerated in 89% of intoxicated patients [43].

The findings reveal substantial heterogeneity in digestive decontamination practices across the MENA region LMICs. Gastric lavage remains frequently practiced in several North African countries despite international recommendations restricting its use [94], whereas its utilization appears limited in Lebanon. This persistence may reflect local practice patterns, limited access to alternative decontamination strategies, or variability in adherence to international recommendations.

The comparatively limited use of activated charcoal is noteworthy given its favorable safety profile and its established role as the preferred gastrointestinal decontamination method for many toxic exposures [95]. Furthermore, reports of delayed gastric lavage in Morocco and unnecessary invasive decontamination procedures in Lebanon suggest ongoing gaps between evidence-based recommendations and clinical practice [10, 96]. These observations highlight the need for standardized protocols, improved toxicology training, and broader access to poison information services to optimize the management of acute poisoning throughout the region.

### Antidote availability and use

The widespread scarcity of specialized antidotes forces healthcare providers in the MENA region LMICs to rely primarily on symptomatic care and decontamination as their main management strategies [52]. This reliance is often a necessity driven by the absence of standardized national guidelines in countries like Libya and Algeria, which forces clinicians to manage life-threatening poisonings on an ad hoc basis [46, 48]. The primary barriers to procurement are economic and logistical, as high procurement costs and short shelf lives make it difficult for budget-constrained facilities to maintain stocks of specialized agents [35, 45]. Clinical management is further complicated by the use of imported antivenoms that may be ineffective against local species and ongoing debates regarding the systematic efficacy of local antivenoms [36, 37, 40]. These systemic challenges are compounded by a lack of comprehensive epidemiological data resulting from widespread underreporting, as well as a lack of official stock guidelines, both of which hinder effective training and the optimization of toxicological care [41].

Collectively, these findings highlight the apparent lack of standardized national protocols for the management of acute poisoning in several MENA countries. The development of evidence-based recommendations adapted to local epidemiology and resource availability may contribute to reducing practice variability and improving the quality of care across the region.

### Extracorporeal therapy

According to the EXtracorporeal TReatments in Poisoning (EXTRIP) Workgroup, extracorporeal toxin removal (ECRT) should be promptly initiated in the early hours following acute poisoning with a dialyzable substance, during the phase when the toxin remains predominantly within the intravascular compartment, as this is the period during which ECRT is most effective in enhancing its elimination [97, 98].

Although diverse patterns of dialyzable toxins are observed across countries in the MENA region, ECRT utilization remain underreported in the literature. This gap highlights that improving extracorporeal treatment capacity requires more than increasing technical availability; it also depends on establishing organized care pathways, including evidence-based patient selection, specialized service centralization, efficient referral systems, and sustained multidisciplinary expertise through the maintenance of trained teams.

In these settings, the application of ECRT should be guided by established consensus recommendations from the EXTRIP workgroup, summarized in **Table 4** [97, 98].

Furthermore, the EXTRIP Workgroup recommends that ECRT be considered not only as a therapeutic intervention but also to prevent progression to severe toxicity in selected cases. Other indications are based

on specific plasma concentration thresholds regardless of symptoms in cases of salicylate, lithium, theophylline, and valproate [97, 98].

When appropriately indicated, the use of ECRT is crucial for improving patient outcomes and may potentially enhance the cost-effectiveness of therapy by reducing the financial burden associated with antidotes, as well as shortening hospital length of stay in these MENA region LMICs.

**TABLE 4 - ECTR Recommendations by Substance According to EXTRIP**

| Substance | Recommendation |
|---|---|
| *Acetaminophen* | **ECTR recommended** when Acetaminophen plasma concentration >1000 mg/L without N-acetyl cysteine (NAC); >700 mg/L with altered mental status, metabolic acidosis and elevated lactate without NAC; or >900 mg/L with these clinical features despite N-AC. |
| *Barbiturates* | **ECTR recommended:** prolonged or anticipated coma; persistent shock despite fluid resuscitation; or persistent toxicity despite Multiple-dose activated charcoal (MDAC).<br>**ECTR suggested:** persistent/rising serum barbiturate concentration despite MDAC; or respiratory depression requiring mechanical ventilation. |
| *Baclofen* | **ECTR suggested** in therapeutic baclofen toxicity in kidney impairment with coma requiring mechanical ventilation |
| *ß-adrenergic antagonists* | **Atenolol:** ECTR **suggested** in severe poisoning with kidney impairment and refractory bradycardia/hypotension.<br>**Sotalol:** ECTR **suggested** in severe poisoning with kidney impairment and refractory bradycardia/hypotension and/or recurrent torsade de pointes. |
| *Carbamazepine* | **ECTR recommended** in multiple treatment-refractory seizures or life-threatening dysrhythmias.<br>**ECTR suggested** in prolonged/anticipated coma or respiratory depression requiring mechanical ventilation; persistent significant toxicity, particularly rising/persistently elevated carbamazepine concentrations, despite MDAC and supportive care. |
| *Ethylene glycol (EG)* | **ECTR recommended**: EG plasma concentration >50 mmol/L with ethanol or >10 mmol/L without an antidote; glycolate plasma concentration >12 mmol/L; anion gap >27 mmol/L; Osmol gap > 50 with ethanol or >10 without an antidote; coma; seizures; or acute kidney injury (KDIGO stage 2–3).<br>**ECTR suggested:** EG plasma concentration > 50 mmol/L with Fomepizole or 20–50 mmol/L with ethanol; osmolal gap >50 with fomepizole or 20–50 with ethanol; glycolate plasma concentration 8–12 mmol/L; anion gap 23–27 mmol/L; or chronic kidney disease (estimated glomerular filtration rate <45 mL/min/1.73 $m^2$). |
| *Gabapentin / pregabalin* | **ECRT Suggested** in severe poisoning with coexisting kidney impairment, especially when coma requires mechanical ventilation. |
| *Isoniazid* | **ECRT Suggested** in seizures refractory to GABAA receptor modulators, when standard dose pyridoxine cannot be administered. |
| *Lithium* | **ECTR recommended:** impaired kidney function with lithium plasma concentration >4.0 mEq/L; or decreased consciousness, seizures, or life-threatening dysrhythmias regardless of lithium concentration.<br>**ECTR suggested:** lithium plasma concentration >5.0 mEq/L; confusion; or expected time to reduce lithium below 1.0 mEq/L >36 hours despite optimal management. |
| *Methanol* | **ECTR recommended:** Coma; seizures; new visual deficits; pH ≤7.15; persistent metabolic acidosis despite treatment; anion gap >24 mmol/L; methanol plasma concentration >700 mg/L with fomepizole, >600 mg/L with ethanol, or >500 mg/L without antidiuretic hormone blockade; informative osmol gap when methanol level unavailable; impaired kidney function. |
| *Metformin* | **ECTR recommended:** Lactate >20 mmol/L; pH ≤7.0; failure of standard supportive measures; shock; impaired kidney function.<br>**ECTR suggested:** Lactate >15 mmol/L; pH ≤7.1; liver failure; decreased level of consciousness. |
| *Phenytoin* | **ECTR suggested:** Prolonged coma present or expected.<br>**ECTR reasonable:** Prolonged incapacitating ataxia present or expected. |
| *Salicylate* | **ECTR recommended:** Salicylate plasma concentration >7.2 mmol/L (100 mg/dL) or >6.5 mmol/L (90 mg/dL) with impaired kidney function; altered mental status; new hypoxemia requiring oxygen; failure of standard therapy.<br>**ECTR suggested:** Salicylate plasma concentration >6.5 mmol/L (90 mg/dL) or >5.8 mmol/L (80 mg/dL) with impaired kidney function; systemic pH ≤7.20. |
| *Thallium* | **ECTR recommended** in severe Thallium poisoning<br>**ECTR suggested** when High suspicion of Thallium exposure based on history/clinical features, or thallium plasma concentration >1.0 mg/L (4.9 µmol/L) |

| | |
|---|---|
| *Theophylline* | **ECTR recommended:** Theophylline plasma concentration >100 mg/L (acute exposure); seizures; life-threatening dysrhythmias; shock; rising theophylline plasma concentration despite optimal therapy; or clinical deterioration despite optimal therapy.<br>**ECTR suggested:** Theophylline plasma concentration >60 mg/L (chronic exposure); age <6 months or >60 years with Theophylline plasma concentration >50 mg/L (chronic exposure); or gastrointestinal decontamination cannot be administered |
| *Valproate* | **ECTR recommended:** Valproic acid plasma concentration >1300 mg/L (9000 µmol/L); shock; or cerebral edema.<br>**ECTR suggested:** Valproic acid plasma concentration >900 mg/L (6250 µmol/L); coma or respiratory depression requiring mechanical ventilation; acute hyperammonemia; or pH <7.10 |

**ECTR:** Extracorporeal Treatments; **EG:** Ethylene glycol; **EXTRIP:** EXtracorporeal TReatments In Poisoning workgroup; **GABAA:** gamma-aminobutyric acid type A; **KDIGO:** Kidney Disease: Improving Global Outcomes organization; **MDAC:** Multiple-dose activated charcoal; **NAC:** N-acetyl cysteine;

## Advanced supportive therapies

Extracorporeal life support (ECLS) should be considered in cases of cardiogenic shock or refractory cardiac arrest secondary to acute cardiotoxic poisoning. In this setting, veno-arterial extracorporeal membrane oxygenation (VA-ECMO) represents the most appropriate modality for short-term circulatory support [99].

Unlike most other causes of cardiogenic shock, acute poisoning is potentially reversible, particularly when functional cardiotoxic agents are involved. This reversibility translates into a more favorable prognosis when adequate support is provided. Conversely, in the absence of circulatory support, mortality in toxic cardiogenic shock is markedly increased, approximately doubling in reported series [100]. Accordingly, indications for VA-ECMO in acute poisonings have become progressively better defined [99].

However, the implementation of VA-ECMO in low-income settings raises major challenges. The first is economic. ECMO remains a highly resource-intensive therapy, with a median cost of approximately 46,308 USD per patient [101], making patient selection critical. In this context, refractory toxic cardiogenic shock without established multiorgan failure appears to be one of the most relevant indications, given its high potential for recovery. In contrast, out-of-hospital cardiac arrest due to poisoning carries a poorer prognosis; nevertheless, carefully selected patients—particularly young individuals with limited comorbidities, short no-flow duration, and early management—may still benefit from VA-ECMO.

The second challenge is organizational. VA-ECMO requires a trained multidisciplinary team capable of rapid initiation, continuous management, and safe weaning. Outcomes are strongly volume-dependent, with higher ECMO activity consistently associated with lower mortality and fewer complications [102]. Maintaining expertise therefore requires a minimum annual caseload, generally estimated at more than 20 cases. In low-resource settings, this strongly supports the centralization of ECMO activity into a limited number of expert centers at the regional or national level. Patients with cardiotoxic poisoning at risk of deterioration should be triaged early toward these centers or managed in facilities allowing rapid transfer. This requires the establishment of structured referral pathways and dedicated transport protocols.

Despite these constraints, several low- and middle-income countries have successfully developed ECMO programs [103,104], demonstrating that implementation is feasible. These experiences suggest that, beyond financial limitations, appropriate organization, centralization, and training are key determinants of success.

## Analytical challenges

Despite the availability of sophisticated platforms, analytical toxicology in LMICs faces severe structural and logistical bottlenecks. The foremost obstacle is the recurrent shortage of reagents and certified reference materials, such as deuterated internal standards, driven by prohibitive costs and complex customs barriers. The clinical implications of limited analytical capacity directly impact patient management, particularly in acute poisonings where timely targeted treatment or antidote administration is critical. Furthermore, the reliance on basic testing hampers the detection and confirmation of emerging toxic substances such as novel psychoactive substances, GHB and complex pesticide formulations leaving local clinicians with diagnostic blind spots. Beyond individual patient care, these analytical limitations restrict toxicovigilance initiatives and national epidemiological surveillance, making it difficult to accurately capture real-world exposure trends or issue timely public health warnings [77–79].

To overcome these constraints, the region must look toward technological innovations like High-Resolution Mass Spectrometry, which allows the identification of unknown substances without immediate reference standards [105].

In order to ensure rapid identification of toxic agents, support timely therapeutic interventions, and optimize clinical outcomes in acute poisoning, a minimum toxicological testing capability should be available across healthcare settings. Table 5 presents a recommended panel of advanced toxicological tests that should be accessible in reference toxicology centers. In addition, a core set of essential toxicological

 

tests should be available in emergency departments, with test selection tailored to the local epidemiology and prevailing patterns of poisoning in each country.

Finally, a standard laboratory evaluation, including arterial blood gas analysis and particularly serum lactate measurement, should be performed, as it constitutes an important tool for guiding the diagnostic approach.

**TABLE 5 - Essential and Advanced Toxicological Tests for Acute Poisoning**

| *Essential Emergency Toxicology Tests* | Advanced/Reference Laboratory Toxicology Tests |
|---|---|
| *Serum paracetamol (acetaminophen) concentration* | Serum carbamazepine concentration |
| *Carboxyhemoglobin (COHb) measurement* | Serum valproic acid concentration |
| *Cholinesterase activity determination* | Serum lithium concentration |
| *Blood ethanol concentration* | Serum theophylline concentration |
| *Blood methanol concentration (where feasible)* | Serum phenobarbital concentration |
| *Rapid screening for major drugs of abuse (e.g., cocaine, MDMA/amphetamines)* | Serum salicylate concentration<br>Detection of new NPS<br>Confirmatory toxicological analyses (e.g., GC-MS, LC-MS/MS) |

COHb = Carboxyhemoglobin, GC = Gas Chromatography , GC-MS = Gas Chromatography-Mass Spectrometry, LC = Liquid Chromatography , LC-MS/MS = Liquid Chromatography-Tandem Mass Spectrometry, MDMA = 3,4-Methylenedioxymethamphetamine, MS = Mass Spectrometry, MS/MS = Tandem Mass Spectrometry, NPS = New Psychoactive Substances

## RECOMMENDATIONS

Although early symptomatic and supportive treatment is sufficient to stabilize most poisoned patients, the use of antidotes remains essential and indispensable for certain types of poisoning. Therefore, based on each country's poisoning epidemiology, a priority list of antidotes—preferably including agents suitable for parenteral administration—should be established and made available in the pharmacies of major healthcare facilities. To optimize antidote availability according to healthcare resources, these agents could be stratified by level of care into essential antidotes, which should be available in all emergency departments, and specialized antidotes, which may be reserved for referral or specialized toxicological centers **(Table 6)**. This proposed classification should consider poisoning frequency, antidote effectiveness, cost, and shelf life **[106]**. Furthermore, a national strategy for antidote storage and distribution should be established in advance within each country **[107]**.

While the antidote list presented in this review provides an overview of agents reported across the region, future initiatives should consider prioritizing antidotes according to epidemiological burden, healthcare level, feasibility, and resource availability. Future guidelines should stratify antidotes into those required in all emergency departments and those reserved for referral or specialized centers.

In addition, access to poison control centers should be strengthened and expanded to ensure timely expert consultation, support clinical decision-making, and enhance toxicovigilance activities.

Finally, particular attention should also be given to the establishment of national poisoning management protocols tailored to local epidemiology patterns, the development of multicenter toxicology registers, the harmonization of reporting systems and collaborative networks among healthcare institutions including emergency department, poison control centers, and analytical laboratories. Collectively, these measures could substantially reduce poisoning-related morbidity and mortality across the MENA LMICs region.

## STRENGTHS AND LIMITATIONS

An important observation emerging from this review is the apparent lack of standardized national protocols for the management of acute poisoning in several MENA countries. Context-specific, evidence-based recommendations informed by local epidemiology and resource availability are needed to reduce variations in clinical practice and strengthen the quality of poisoning care across the region.

However, we acknowledge some limitations in this review. Several epidemiological findings presented in this review should be interpreted with caution, as the available evidence largely originates from single-center studies, poison center reports, or geographically restricted retrospective analyses. Consequently, these data may not fully reflect national poisoning patterns and should not be considered representative of the entire populations of the countries concerned. Furthermore, differences in healthcare organization, reporting systems, and research productivity across MENA countries may also contribute to the epidemiological patterns described in the literature.

**TABLE 6 - Priority Antidotes Recommended for Stocking in Healthcare Facilities and Their Main Toxicological Indications**

| *Recommended Level of Availability and advised level of storage* | Antidote | Toxic Agent / Indication |
|---|---|---|
| *Immediate (All emergency departments, including those of regional hospitals)* | Activated charcoal | Adsorbable toxins and toxins undergoing enterohepatic circulation |
| | NAC | Paracetamol (Acetaminophen) |
| | Atropine | Organophosphate and carbamate cholinesterase inhibitors |
| | Flumazenil | Benzodiazepines and related drugs |
| | Naloxone | Opioids |
| | Vitamin K | Anticoagulant rodenticides and vitamin K antagonist drugs |
| | Ethanol | Methanol, Ethylene Glycol |
| | Sodium bicarbonate (8.4%) | Toxins causing QRS widening (membrane-stabilizing effect) |
| | Specific antivenoms | Scorpion and viper envenomation |
| | Insulin / Glucose (High-dose insulin euglycemia therapy) | Beta-blocker and calcium channel blocker poisoning |
| | Hydroxocobalamin | Cyanide poisoning |
| | Pralidoxime | Organophosphate poisoning |
| *Delayed (Central pharmacy)* | Fomepizole | Methanol, Ethylene Glycol |
| | Digoxin-specific antibody fragments (Digoxin immune Fab) | Digitalis (digoxin) poisoning |
| | Deferoxamine | Iron salts poisoning |
| | L-carnitine | Valproic acid poisoning |
| | Calcium disodium EDTA | Lead poisoning |
| | DMSA (Succimer) | Lead, mercury, and arsenic poisoning |
| | Octreotide | Sulfonylurea-induced hypoglycemia |
| | Physostigmine | Anticholinergic syndrome |
| | Cyproheptadine | Serotonin syndrome |
| | Methylene blue | Methemoglobin-inducing agents (methemoglobinemia) |
| | Glucagon | Beta-blocker and calcium channel blocker poisoning |

DMSA = Dimercaptosuccinic Acid (Succimer) , EDTA = Ethylenediaminetetraacetic Acid , Fab = Fragment Antigen-Binding , NAC = N-Acetylcysteine , QRS = QRS Complex (electrocardiographic waveform representing ventricular depolarization),

## CONCLUSION

The management of acute poisoning remains a major challenge in MENA region LMICs, where limitations in antidote availability, toxicological diagnostic capacity, poison information services, and access to advanced supportive therapies such as ECLS continue to affect patient care. Ensuring that pharmacies in major healthcare institutions stock priority antidotes corresponding to prevalent regional intoxications is essential, in addition to strengthening poison control systems. Together, these interventions have the potential to improve outcomes, reduce preventable mortality, and strengthen the overall response to acute poisoning in the MENA region LMICs.

## Keywords

Acute poisoning, Clinical toxicology, Emergency medicine, Antidote availability, Poison control center, ECMO, Analytical toxicology, Low- and middle-income countries, Middle East and North Africa

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All authors contributed equally and validated the final version of record.

## Declarations

### Conflicts Of Interest

The Authors declare that there is no conflict of interest.

### Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

### Registration

No registration applicable.

### Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### Ethical approval

Ethical approval for this study was not required.

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