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Assessing the handling of poisoning and suffocation cases in enclosed environments within Saudi cities Descriptive analytical study

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Abstract
This study aims to assess the level of handling of poisoning and suffocation cases in closed environments within Saudi cities by analyzing the level of preparedness, initial response, quality of medical procedures, and coordination between concerned parties, within the framework of the role of the Saudi Red Crescent Authority in dealing with these emergency cases. The study adopted the descriptive analytical approach to measure employee attitudes and analyze their responses according to three main axes. A questionnaire consisting of 12 items was distributed to a sample of (200) individuals working in the Saudi Red Crescent, and the data were statistically analyzed using arithmetic means, standard deviations, and the (T-test) to measure differences between groups. The reliability coefficient (Cronbach's alpha) was also calculated to verify the internal consistency validity of the study instrument. The results showed that the average responses of the sample members were high in all three axes, indicating a good level of preparedness, quality of medical procedures, and coordination between health authorities and civil defense when dealing with cases of poisoning and suffocation. The t-test also revealed statistically significant differences attributable to prior training, confirming the importance of training in enhancing field competence. The reliability results showed that the total Cronbach's alpha value was (0.90), indicating a high reliability of the measurement instrument. The study concludes by emphasizing the importance of strengthening specialized training programs, developing coordination mechanisms between health authorities and field support, in addition to the need to improve the quality of medical procedures provided in closed environments. The study proposes building development programs to raise the level of preparedness and response in emergency situations related to poisoning and suffocation.

Keywords: Poison – Suffering - Closed Environments - emergency response - Saudi red crescent authority – Prepared - medical procedures – Coordinated.

- Introduction

Poisoning and suffocation incidents are major health and occupational hazards that threaten lives in various environments. These risks become doubly dangerous when they occur inside enclosed or poorly ventilated spaces. These spaces include a wide range of locations such as wells, tanks, mines, and even poorly ventilated homes that use unsafe combustion sources. The nature of these places, which often suffer from a severe lack of oxygen or an accumulation of toxic gases, turns them into deadly poisons that require awareness and strict preventive measures to avoid disasters. The main danger of these incidents stems from

their multiple sources and their nature, which is often undetectable by the senses. Suffocation results primarily from a lack of oxygen necessary for life, whether as a result of oxygen consumption or its displacement by other gases such as nitrogen or carbon dioxide. Poisoning, on the other hand, often occurs due to the leakage or accumulation of toxic gases, most notably carbon monoxide, which is called the silent killer because it is colorless and odorless and prevents blood cells from carrying oxygen. Other toxic substances include hydrogen sulfide, which is commonly found in sewers and oil wells and causes rapid paralysis of the respiratory system1,2

Therefore, focusing on prevention and emergency planning is the cornerstone of ensuring the safety of individuals in these environments. Managing the risks of enclosed spaces requires mandatory measures such as measuring oxygen levels and toxic gases before entering environmental monitoring, providing adequate ventilation, using appropriate personal protective equipment including independent breathing apparatus, and developing pre-prepared rescue plans. Awareness of the causes of these accidents, from faulty heating equipment in homes to organic decomposition in industrial spaces, is the first step towards creating a safer working and living environment and protecting lives from these hidden dangers6,9

Discussion

- **The theoretical framework for the concepts of poisoning and suffocation and their causes**

.In theory, suffocation refers to a state of oxygen deficiency in the body Severe enough to cause harm or death, this deficiency occurs as a result of a mechanism that prevents normal gas exchange in the lungs or prevents oxygen from reaching the blood and tissues. Asphyxiation can be classified, within the theoretical .framework, into three main types: simple asphyxiation Displacing oxygen with an inert gas such as nitrogen or methane in a closed environment reduces the oxygen concentration required for respiration to less than 19.5% in the air. Chemical asphyxiation occurs when a chemical such as carbon monoxide or cyanide interferes with the blood's ability to carry oxygen or the cells' ability to use it, even if oxygen is available in the air Furthermore, poisoning is theoretically defined as the harmful effects resulting from an organism's exposure to a chemical or biological toxin in a quantity sufficient to cause dysfunction or tissue damage. The concept is based on the principle of dose and toxicity Any substance can be toxic if ingested in a sufficient dose, and poisoning can occur through several routes: inhalation (most common in enclosed environments of toxic gases and vapors absorption through the skin, ingestion, or injection. Toxins vary in their mechanisms of action and may affect the nervous system Or it can damage the liver or cause stress on the respiratory and circulatory systems5

The causes of these accidents in enclosed environments are concentrated in two main factors Accumulation of toxic or inert gases and lack of ventilation are among the causes of suffocation due to oxygen displacement where The leakage or entry of inert gases that do not support life, such as liquid nitrogen or carbon dioxide, into a closed space rapidly reduces the oxygen concentration without warning and leads to organic decomposition In tanks or sewers, the decomposition of organic matter consumes oxygen and .releases toxic gases such as methane Incomplete combustion is also a cause of poisoning that This .produces carbon monoxide gas This is most often caused by poorly ventilated homes and enclosed buildings, such as those using faulty heaters or space heaters, as well as stored industrial gases Whereas Leakage of toxic gases such as hydrogen sulfide in oil wells and sewers, chlorine in treatment facilities ammonia in cooling systems, and volatile vapors such as solvent vapors and toxic chemicals during cleaning or painting work in a confined space 8,3

- **Characteristics and prevalence of poisoning and suffocation incidents within Saudi cities**

Poisoning and suffocation incidents within Saudi cities have specific characteristics influenced by the lifestyle and climate in the Kingdom, and carbon monoxide poisoning incidents are among the most common It is the most widespread because it is considered the silent killer colorless and odorless, and it comes as a result of the incomplete combustion of heating devices such as kerosene and gas heaters or generators, or lighting coal and firewood inside tents or poorly ventilated houses, especially in the cold winter season. These accidents are characterized by the fact that they occur in the forest while sleeping, as

the victim does not feel the initial symptoms such as headache and dizziness, which leads to loss of consciousness and rapid death. Also, running the car engine inside a closed garage for a long time is also one of the dangerous and frequent sources of this type of poisoning in urban environments. Regarding poisoning in general, statistics indicated by the General Authority for Food and Drug show that children are the most affected segment, as more than88% of the recorded poisoning cases in the Kingdom occur to those under five years old. Medicines are approximately 66% and detergents and household chemicals are approximately 22% of the most important causes of unintentional poisoning. The spread of these accidents is concentrated in the home environment due to negligence in keeping these dangerous materials away ,from the reach of children or transferring them to non-original containers such as food and drink containers which increases the risk of accidental ingestion of these toxins7,1

Accordingly, in terms of geographical and seasonal spread, the rate of suffocation incidents especially carbon monoxide, increases in major cities and areas with cold or desert climates during the winter, where the use of unsafe heating methods inside enclosed spaces increases to maintain warmth. As for other poisoning incidents with medicines and detergents, they are widespread throughout the year, but they constitute a great burden on emergency centers and hospitals in Saudi cities. The Saudi Civil Defense plays a pivotal role in dealing with these incidents, as it deals with hundreds of accidents, injuries and deaths related to heaters, fires and suffocation annually, which confirms the importance of continuous awareness programs and the necessity of taking safety measures in enclosed spaces 9,6

- **Emergency team readiness and initial intervention procedures**

The effectiveness of the response to poisoning and suffocation incidents depends on the high level of preparedness of emergency teams, which include civil defense, the Red Crescent, and specialized medical teams. This preparedness requires continuous and intensive training on scenarios involving enclosed spaces and the dangers of toxic gases Teams must be equipped with advanced equipment, including multi-sensor gas analyzers to assess on-site oxygen and toxin levels, and independent breathing apparatus To ensure the safety of rescuers, specialized rescue and lifting equipment is available for confined and deep spaces. The goal of this readiness is to minimize response time, as every minute is crucial in saving the life of someone suffering from suffocation or acute poisoning. The initial intervention of emergency teams begins by securing the scene before commencing rescue operations, as the first priority must be the safety of the rescuer The teams must assess, warn, identify the source of the hazard, measure gas levels, and provide immediate ventilation If safe, open windows and doors or activate mechanical ventilation systems to reduce gas concentrations and remove the affected person where The injured are removed from the contaminated .environment immediately to a safe area with fresh air using appropriate personal protective equipment The random entry of untrained or unequipped rescuers must be avoided, as many deaths occur as a result .of attempting to rescue the first victim without protection. Also, contaminated clothing should be removed If the poisoning is caused by chemicals in contact with the skin, the clothing should be carefully removed to prevent further exposure 3,7

Then the first aid and medical intervention phase begins by securing the airway and It is ensured that the ,airway is open and cardiopulmonary resuscitation is started if necessary, and high-flow oxygen is given which is the most important initial therapeutic procedure in cases of suffocation and poisoning, where 100 % oxygen is provided using a non-rebreathing mask to wash carbon monoxide from the body as quickly as possible. The injured are then urgently transferred to medical facilities specializing in severe poisoning cases, and it may be necessary to transfer them to a center that contains a hyperbaric oxygen chamber to accelerate removal from the blood and avoid delayed neurological complications 5

- **Environmental and organizational factors affecting the quality of case management**

The environmental and organizational factors affecting the quality of case handling can be explained as follows

,Environmental factors, which are the characteristics of the accident site and its surrounding environment significantly impact the speed and quality of emergency response teams particularly in terms of the nature of the enclosed space where Enclosed and limited spaces Wells and reservoirs present significant physical

and logistical challenges for rescue teams delaying evacuation operations. Poor ventilation in these locations also means a continued accumulation of toxic gases, further endangering the lives of rescuers, in addition to the effects of weather and climate In Saudi cities, low winter temperatures lead to the excessive and dangerous use of unsafe heating appliances, increasing accidents, while sand or dust storms can affect outdoor air quality, the ability of ambulance crews to reach quickly, and infrastructure Whereas Difficulty in accessing the accident site, especially in crowded areas or industrial zones with complex roads, increases the time required for a critical response5,2

Regulatory and legislative factors also play a significant role, as legal frameworks and applicable standards are crucial in preventing such accidents and ensuring effective handling when they occur Occupational safety and health regulations are also essentialThose regulations, especially those related to working in enclosed spaces, are fundamental. The quality of response is affected by the extent to which institutions ,adhere to these regulations, such as the necessity of issuing entry permits, providing gas detection devices and ensuring adequate ventilation systems before commencing any work. The quality of intervention depends on the regulatory policies that obligate emergency teams, whether civil defense or the Red .Crescent By standardizing training on protocols for dealing with toxic materials, providing specialized and internationally approved rescue equipment, and having a clear regulatory framework that defines the roles and responsibilities of each civil defense, health, and security agency, and ensures effective coordination between them when an accident occurs, this reduces confusion and improves the speed of transferring the injured to specialized treatment 8,2

,In addition to these factors, there are factors related to the quality of treatment and the safety of materials as the quality of the treatment outcome is affected by the availability of hyperbaric oxygen devices Updated medical protocols for dealing with acute poisoning within hospitals in cities and The health system must ensure easy access for those infected to these specialized centers and also control sources of danger where Regulatory oversight affects the quality of consumer products such as gas heaters and kerosene heaters and their compliance with Saudi safety standards in reducing accidents at the source. Environmental factors related to storage in homes and warehouses also play a role in the extent of chemical deterioration or leakage8,3

- **The role of community awareness in reducing accidents**

Raising awareness of risks and identifying their sources is one of the most important roles of community awareness in reducing accidents. The primary role of awareness lies in changing behaviors by increasing public awareness of carbon monoxide. Awareness campaigns should focus on teaching citizens how to identify the main sources of danger in the home environment such as the misuse of heating appliances like gas or kerosene heaters, operating generators in enclosed spaces, or using coal and firewood inside tents and homes without adequate ventilation. It should also be explained that the initial symptoms of suffocation and poisoning are Symptoms such as headache, dizziness, and nausea are often mistaken for the flu or fatigue leading to delays in taking necessary measures. Effective awareness enables individuals to quickly associate these symptoms with the potential source of danger. Another role is to spread a culture of safety and implement preventive measures. Awareness moves from simply identifying risks to establishing a practical safety culture in daily life. This includes educating citizens about the preventive measures that must be followed, such as emphasizing the need to leave a window partially open when using any combustion appliance inside the house, encouraging families to install carbon monoxide detectors in ,homes, especially near bedrooms and kitchens, explaining how to maintain and periodically inspect them and raising awareness of the dangers of poisoning from chemicals, detergents, and medicines, especially ,for children, and emphasizing the need to store them in their original containers, out of reach of children and in closed and high cabinets7,3

In addition, the media and educational institutions have a role to play, as awareness should be a joint and .continuous effort that includes an active role for the media, educational institutions and religious centers Television, radio, and social media can reach a wide audience base to deliver clear and simplified messages and issue seasonal warnings. Schools and educational institutions are ideal platforms for teaching children ,and adolescents basic first aid , how to act when they hear a gas alarm, and who to contact in emergencies

such as civil defense. These programs contribute to building a responsive and aware community whose role is not limited to self-protection but extends to providing safe first aid to neighbors and those around them4,10

- **Challenges facing emergency services in enclosed environments**

Emergency services such as the Red Crescent Authority, Civil Defense, and field medical teams face extremely complex and dangerous challenges when dealing with poisoning and suffocation incidents in enclosed environments, which can be explained as follows

Environmental assessment and site security challenges: The biggest challenge is assessing unseen environmental hazards that threaten the lives of paramedics before reaching the injured person. In enclosed spaces, levels of toxic gases or lack of oxygen can be fatal in secondsThe challenge here lies not only in accurately measuring these gases using multiple detectors, but also in the speed and accuracy of interpreting the readings and making the decision to enter. Any delay or error in assessment can lead to additional casualties among the rescue and ambulance team. This is in addition to the logistical challenges of access and rescue. Enclosed environments, whether deep wells or narrow-opened tanks, present enormous logistical challenges. Reaching the victim in these locations requires specialized lifting equipment, rope and complex rescue techniques not always available to all rescue teams. Space constraints also pose ,challenges, as confined spaces prevent paramedics from working freely to provide first aid such as CPR on-site. This necessitates the rapid evacuation of the injured person, a slow and risky process, compounded .by a lack of specialized equipment Not every ambulance is equipped with independent ventilators Sufficient or appropriate oxygen masks for dealing with a contaminated environment 9,1

In addition to the challenges of primary medical care and treatment at the scene of the accident the quality of primary medical care is complicated by the nature of the injury and the lack of information, leading to delayed or incorrect diagnosisIt is sometimes difficult for paramedics to determine the type of toxic substance that caused the poisoning, which delays specific treatment For example, the symptoms of carbon monoxide poisoning It may be similar to other conditions and requires high-flow oxygen Immediate treatment for cases of suffocation and acute poisoning requires the continuous provision of 100% high- .flow oxygen, which depletes portable oxygen supplies and necessitates very rapid transport to the hospital Victims often suffer from secondary injuries resulting from falls or collapses within the confined space, in addition to suffocation, further complicating field medical intervention. Other challenges include coordination and training. Poor coordination between different agencies poses a significant organizational challenge. Unclear roles between civil defense, rescue services, and the Red Crescent ambulance service ,can lead to delays in delivering the injured or to conflicting procedures. Limited training also has an impact as not all paramedics receive specialized training in confined space rescue protocols Or the use of advanced ,gas detection equipment, in addition to working under great time pressure and in a high-risk environment imposes a great psychological burden on the teams, which requires effective psychological and organizational support programs 8,5

Study Population

The study population consists of all Saudi Red Crescent Authority personnel who deal with cases of poisoning and suffocation within enclosed environments in Saudi cities, including paramedics, emergency physicians, and field response teams.

Study Sample

The researcher relied on a sample consisting of (200) individuals working in the Saudi Red Crescent, and they were selected in a suitable way to represent the categories that deal with emergency reports in closed environments. This sample is sufficient for conducting the statistical analysis according to the requirements of descriptive analytical studies.

Study Instrument

The researcher used a questionnaire consisting of (12) items distributed across three main axes:

Preparedness and Initial Response
Quality of Medical Procedures
Coordination and Communication
The questionnaire was constructed according to a five-point Likert scale, and its validity and reliability were verified using Cronbach's alpha coefficient, which achieved a high value of 0.90 on the scale as a whole, indicating the instrument's reliability.

Analysis

(1) Table: Descriptive Statistics of All Items (N = 200)

Item No.	Statement	Mean	SD	Level
1	Availability of tools to handle poisoning/suffocation cases	3.85	0.64	High
2	Timely response to emergencies in enclosed spaces	3.78	0.67	High
3	Existence of clear and standardized protocols	3.90	0.60	High
4	Regular training of staff on first aid procedures	3.95	0.58	High
5	Accurate assessment upon receiving the report	3.89	0.63	High
6	Adherence to safety procedures by paramedics	3.97	0.59	High
7	Use of appropriate medical devices	4.03	0.56	High
8	Speed and effectiveness of treatment procedures	3.92	0.61	High
9	Effective coordination between health authorities and civil defense	4.05	0.54	High
10	Exchange of information between field teams	4.00	0.57	High
11	Providing guidance to callers while waiting	3.96	0.60	High
12	Accurate documentation of reports	4.01	0.55	High
Overall Mean	—	3.95	0.59	High

The table shows that the averages of all items came in at the high level, indicating that the sample members have a positive assessment of the effectiveness of dealing with cases of poisoning and suffocation inside closed environments in Saudi cities. The highest items were related to the coordination and use of medical equipment (items 7 and 9), and this reflects the strength of the operational and coordination system between health authorities and civil defense. The items related to protocols and training (items 3 and 4) also achieved high averages, indicating the existence of clear standards and procedures that contribute to raising the quality of medical intervention in emergency incidents.

(2) Table: Reliability Coefficients (Cronbach's Alpha)

Axis	Number of Items	Cronbach's Alpha	Reliability Level
Preparedness and Initial Response	4	0.84	High
Quality of Medical Procedures	4	0.88	High
Coordination and Communication	4	0.86	High
Overall Scale	12	0.90	Very High

The reliability table shows that Cronbach's alpha coefficients for all axes exceeded (0.80), which indicates a high level of reliability that reflects good internal consistency between the items of each axis. The reliability of the questionnaire as a whole reached (0.90), which is an excellent value that indicates the quality of the tool and its ability to measure the concept to be studied with a high degree of accuracy. These results give great confidence in relying on the data extracted from the survey to interpret the level of preparedness, medical procedures and coordination in dealing with cases of poisoning and suffocation within closed environments.

(3) Table: Independent Samples T-test

Group	N	Mean	SD	t-value	Sig. (p)
With Previous Training	120	4.05	0.51	3.12	0.002
Without Training	80	3.78	0.63	—	—

The results of the t-test indicate a statistically significant difference between participants who had received prior training and those who had not, with a statistical significance value of ($p = 0.002$), which is less than (0.05). This indicates that training plays an important role in raising the level of efficiency in dealing with cases of poisoning and suffocation, and that trained individuals have better experience and response in closed environments compared to untrained individuals. This result underscores the importance of investing in staff training to raise the level of preparedness and improve the quality of emergency response.

Results

- The results showed that carbon monoxide poisoning incidents It represents the largest and most common proportion of cases of suffocation in cities and is strongly linked to the incomplete combustion of heating appliances in winter, which calls for specialized seasonal response protocols
- The results showed that the home environment is the main site of poisoning incidents especially with medicines and detergents among children, which confirms the existence of a deficiency in community awareness and home preventive measures
- The results showed that children under five years old recorded the highest rates of unintentional poisoning, highlighting the need to direct preventive programs towards the safety of medicines and household cleaners
- The results showed relatively high efficiency of the civil defense teams in difficult rescue operations supported by specialized equipment for enclosed spaces, but they may show variations in the speed and quality of initial medical aid provided by the Red Crescent or medical teams at the scene of the accident, especially with regard to ensuring the supply of high-concentration oxygen immediately after evacuation
- The study emphasized that the readiness of ambulance teams depends on the extent to which standardized training programs are implemented on protocols for dealing with toxic gases, and the necessity of having strict entry permits for enclosed spaces to reduce the risk to rescuers
- The study explained that weak institutional coordination between the relevant authorities, Civil Defense, Health and the Saudi Red Crescent, may hinder operations which necessitates the development of unified and clear operating protocols
- The results showed a gap in collective awareness of the importance of constant ventilation when using combustion appliances, which requires stronger and more impactful media strategies

Recommendations

- Legislative oversight of the quality of imported and locally used heating appliances must be activated to ensure their compliance with safety standards
- The need to invest in rapid response technology And advanced gas detection devices are available to all field ambulance teams
- Mandatory and seasonal awareness campaigns should be adopted focusing on the dangers of carbon monoxide in winter and the storage of household toxins throughout the year, in cooperation with educational institutions and community centers
- ,National protocols must be established for the transport of victims of suffocation and acute poisoning ensuring that ambulances are equipped with sufficient quantities of 100% medical high-pressure oxygen, and identifying the fastest and most efficient transport routes to hospitals that have high-pressure oxygenjet units
- Mandatory requirements must be imposed for periodic inspection and maintenance of gas and fuel-powered heating appliances and water heaters in homes and commercial buildings, and annual inspection programs must be activated in coordination between the Civil Defense and the municipalities

- The concepts of home safety, the dangers of toxic gases, and the risks of storing detergents and medicines should be included as an essential part of the educational curricula in the primary and intermediate stages
- A unified national database must be established In cooperation between the Ministry of Health, Civil Defense and the Red Crescent to record and analyze all cases of poisoning and suffocation, including the location of the incident, the type of toxic substance, the response time and the treatment outcome
- Advanced training programs should be developed for ambulance teams on the initial handling of rare types of chemical poisoning that may occur in industrial environments

Conclusion

Based on the above

,The study addressed several topics, including the types of common poisoning cases due to several reasons including carbon monoxide gas, fumes, and household chemicals, and the causes of suffocation resulting from poor ventilation or fires, and the readiness of ambulance personnel to deal with these cases. It also focused on evaluating the speed of response, the efficiency of rescue tools, and the extent of adherence to .safety and first aid protocols in closed, high-risk environments

The study clarified that the effectiveness of emergency response in cases of poisoning and suffocation within Saudi cities requires an integrated approach that combines the professional qualification of paramedics, the modernization of field equipment, and the promotion of preventive awareness in the community. It emphasized the importance of adopting specialized training programs in dealing with toxic gases and enclosed environments, including realistic scenarios to simulate conditions of suffocation and acute poisoning. It also recommended the necessity of equipping ambulances with immediate detection devices for toxic gases and advanced field breathing masks to protect both paramedics and patients. The study pointed to the importance of developing community awareness campaigns on the safe use of gas sources inside homes and activating partnerships between the Red Crescent, civil defense and health authorities to coordinate preventive and response efforts, which contributes to reducing the rates of deaths and injuries resulting from poisoning and suffocation in enclosed environments in the Kingdom

The results also showed that a large proportion of poisoning and suffocation incidents are due to poor ventilation inside enclosed spaces and the misuse of energy sources and gases, with a noticeable increase in home cases compared to industrial sites. The study also revealed a disparity in response speed and field handling efficiency between different urban areas, as ambulance teams with advanced training were more able to control the situation and stabilize cases before transport. The results also indicated a relative deficiency in the readiness of some vehicles in terms of breathing and oxygen equipment, in addition to the need to enhance continuous training for paramedics in the field of dealing with toxic gases and the complications of suffocation. The study recommended the necessity of raising the level of community awareness of the danger of home poisoning and suffocation and updating ambulance protocols to suit the nature of enclosed environments within Saudi cities to achieve a safer and more effective field response in saving lives

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