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Public Health Responses to CBRN Terrorism in the Middle East and North Africa

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Original Research

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Abstract

Objective: Escalating global challenges (such as disasters, conflict, and climate change) underline the importance of addressing Chemical, Biological, Radiological, and Nuclear (CBRN) terrorism for sustainable public health strategies. This study aims to provide a comprehensive epidemiological analysis of CBRN incidents in the Middle East and North Africa (MENA) region, emphasizing the necessity of sustainable responses to safeguard healthcare infrastructures.

Method: Utilizing a retrospective approach, this research analyzes data from the Global Terrorism Database (GTD) covering the period from 2003 to 2020. The study focuses on examining the frequency, characteristics, and consequences of CBRN incidents in the MENA region to identify patterns and trends that pose significant challenges to public health systems.

Results: The analysis revealed a significant clustering of CBRN incidents in Iraq and Syria, with a predominant involvement of chemical agents. These findings indicate the extensive impact of CBRN terrorism on healthcare infrastructures, highlighting the challenges in providing immediate health responses and the necessity for long-term recovery strategies.

Conclusions: The study underscores the need for improved healthcare preparedness, robust emergency response systems, and the development of sustainable public health policies. Advocating for international collaboration, the research contributes to the strategic adaptation of healthcare systems to mitigate the impacts of CBRN terrorism, ensuring preparedness for future incidents in the MENA region and beyond.

Introduction

In an era marked by an unsettling evolution in conflict, the intensification of terrorist activities, particularly in the Middle East, and North Africa (MENA) region poses unprecedented challenges to global security, and public health. Over 46 000 attacks (including the potential use of chemical, biological, radiological, and nuclear (CBRN) agents) have been reported in the MENA region from 2003 to 2020, making it a hotspot for terrorism.[1,2] It was stated that "the first time a chemical weapon capable of killing hundreds of thousands to millions was available for purchase, was on the street or from the dark web."[3] The consequences of these are far-reaching, straining healthcare systems, causing long-term health complications, and necessitating innovative approaches like Counter-Terrorism Medicine (CTM) which has now been established as a new discipline.

These terrorist attacks have repercussions that echo far beyond immediate destruction and loss of life. They disrupt social structures, incite fear, as well as mistrust, and impose an enormous strain on healthcare systems in both short- and long-term perspectives. From 2003 to 2020, the pattern of complexity in these attacks has expanded to include unconventional tactics and psychological warfare, further compounding the challenges of defence and response.[1,4] While conventional forms of terrorism continue to wreak havoc, the accessibility of mass-casualty weapons (including CBRN agents) intensifies the potential destruction of these attacks, leading to mass casualty incidents, and putting the lives of frontline health care providers at grave risk.[5] These weapons, combined with the use of various sophisticated technologies such as drones, pose unfamiliar threats with intricate methods of attack.[6]

The severity and complexity of this growing threat have not gone unnoticed. In response, the field of Disaster Medicine has considered this issue with utmost seriousness. CTM represents an innovative, pro-active approach to address this emerging threat, aiming to develop cutting-edge research, and education programs to enhance healthcare provider preparedness, as well as response for any man-made incident.[7–9]

In an era characterized by an ever-evolving landscape of threat, our defences and strategies must adapt accordingly. Utilizing a rigorous, evidence-based approach, we intend to provide a comprehensive epidemiological description of CBRN attacks. This will entail a meticulous analysis of the types of weapons used, the nature of these attacks, and their consequent injury patterns. By grounding this research in empirical evidence, we aim to offer an authoritative account of the CBRN threat landscape in the MENA region.

In addition to unravelling the mechanisms of these attacks, the research aims to assess the toll they take on human lives and healthcare infrastructures. The consequences of CBRN attacks are far-reaching and devastating, affecting not just the immediate victims, but also stretching the resources of health systems to their limits.[10] Recent examples of such incidents show the need for increased resilience in healthcare infrastructures, heightened medical preparedness, as well as the crucial importance of swift, and effective response mechanisms. A thorough understanding of the potential fallout from these weapons can provide invaluable insights into developing effective countermeasures and safeguards for healthcare providers and systems alike.[10]

The results derived from this study will not only enhance our understanding of these formidable threats but also serve as an indispensable resource for healthcare providers. Through meticulous analysis and data interpretation, the study aims to better inform training programs, equipping healthcare providers with the knowledge to anticipate the type of injuries and potential attacks they might confront. This anticipatory knowledge could prove to be a game-changer, enhancing preparedness, and shaping response strategies to be more targeted and effective.

Transforming the theoretical knowledge derived from this research into practical preparedness and response strategies is critical. This is no trivial pursuit, the gravity of the threat demands practical solutions, and actionable measures that can be implemented in real-world scenarios. By demystifying the complexities of CBRN attacks, we aspire to turn the fear of the unknown into a defined set of response strategies, empowering those on the frontlines of healthcare to tackle these threats head-on.

In the face of disturbing CBRN threats, this research represents more than an academic endeavour. It seeks to provide practical, actionable strategies in the global fight against terrorism. Each counter-terrorism success signifies a triumph for humanity. Our shared responsibility is to mitigate these risks, enhance healthcare system resilience, and foster global cooperation. By translating theory into practice, this research aims to turn the tides in our favour, providing real-world solutions that save lives and protect communities.

The primary objective of this work was to conduct a comprehensive epidemiological analysis of CBRN incidents in the MENA region between 2003 and 2020, examining their frequency, modalities, and impacts.

Materials and Methods

Study Design

A retrospective study was conducted to investigate CBRN incidents in the MENA region, utilizing the Global Terrorism Database (GTD).[11] This comprehensive and open-access database details terrorism-related incidents and adheres to the specific 2021 GTD definition of terrorist attacks as "the threatened or actual use of illegal force and violence by a non-state actor to attain a political, economic, religious, or social goal through fear, coercion, or intimidation."[11]

The methodology employed in this research allows for a rigorous examination of CBRN incidents in the MENA region over the studied period. By utilizing a well-established database and applying a systematic approach to data collection and analysis, this study establishes a solid foundation for interpreting the complex landscape of CBRN threats within a region that is particularly susceptible to terrorist activities. The findings derived from this methodological approach will contribute significantly to the broader understanding of CBRN threats.

Data Collection

Data were collected from GTD for the years 2003 to 2020, with a focus on the MENA region. The inclusion criteria for the database search included parameters such as CBRN weapon type, date of incident, perpetrator group, and target type, as well as country, city, number of injuries, and fatalities. Data for 2021 - 2023 were not available at the time of the search.

Data Analysis

The extracted data were exported into an Excel sheet for further analysis. A quantitative approach was adopted, applying descriptive statistics to delineate patterns and trends relevant to CBRN incidents in the MENA region. This included evaluations of percentages, frequencies, and distributions across various categorical parameters.

Results

Over the study period, a total of 84 such incidents were identified, spanning across several countries including Iraq, Syria, and Palestine, as well as Yemen, Israel, Iran, and Tunisia. These incidents are further detailed in Table 1.

Total number of deaths resulting from these incidents was 205, while the total injuries were reported to be 2205. Iraq had the grim distinction of experiencing 2 catastrophic CBRN incidents in 2016: the first incident, involving the use of a weaponized form of Chlorine gas, resulted in the highest number of deaths, and a total of 72 fatalities. The second incident, which involved the use of rockets armed with mustard gas, resulted in the highest number of injuries, causing harm to 1500 individuals.

To provide a more detailed perspective, these 2 incidents not only stood out in the country's history but also on the global scale of CBRN events. Such high fatality and injury rates emphasize the severity and potential devastating impacts of CBRN events in a war-like situation.

Despite considerable international efforts for disarmament and prevention, these incidents demonstrate that the use of CBRN materials as weapons of war and terror continues to be a significant threat. Furthermore, the concentration of these incidents in areas of conflict underscores the strategic significance of CBRN materials and the importance of further efforts in preventing their misuse.

Table 2 provides an overview of the number and proportion of CBRN incidents across various countries in the Middle East. Iraq clearly stands out, having reported 57 incidents, or 68.67% of the total. Syria is second, contributing 13 incidents (15.66%), followed by Palestine with 6 incidents (7.23%), and Israel with 3 (3.61%). Yemen, Iran, and Tunisia each reported fewer incidents;

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Table 1. CBRN incidents in the Middle East

Date	CBRN Weapon	Country	City	Perpetrator group	Death	Injury	Target types
2007	Poisoned food	Iraq	Hillah	Unknown	0	0	Private Citizens and Property
2007	Explosives and chlorine gas	Iraq	Ramadi	Al-Qaida in Iraq (suspected)	2	2	Military, Military
2007	Explosives and chlorine gas	Iraq	Amriyat al-Fallujah	Al-Qaida in Iraq (suspected)	2	100	Police, Private Citizens, and Property
2007	Explosives and chlorine gas	Iraq	Albu Issa	Al-Qaida in Iraq (suspected)	1	250	Police, Private Citizens, and Property
2007	Chlorine gas	Iraq	Ramadi	Unknown	20	30	Police
2007	Chlorine gas	Iraq	Ramadi	Unknown	3	9	Police, Private Citizens, and Property
2007	Chlorine gas	Iraq	Baqubah	Unknown	1	0	Military
2009	Chlorine gas	Iraq	Khan Bani Saad	Unknown	1	8	Military, Private Citizens, and Property
2011	Unknown	Iraq	Qaim	Unknown	1	0	Unknown
2013	Unknown	Iraq	Baghdad	Unknown	1	0	Educational Institution
2013	A rocket loaded with unidentified chemical agents	Syria	Khan al-Assal	Unknown	25	130	Military, Private Citizens, and Property
2014	Unknown	Palestine	Bethlehem	Unknown	0	0	Religious Figures/Institutions
2014	Chlorine gas	Syria	Kafr Zita	Al-Nusrah Front	2	101	Private Citizens and Property
2014	Unknown	Palestine	Nablus	Israeli settlers	0	1	Private Citizens and Property
2014	Unknown	Israel	Jerusalem	Israeli settlers	0	1	Private Citizens and Property
2014	Chlorine gas	Iraq	Dhuluiya	Islamic State of Iraq and the Levant (ISIL)	0	4	Private Citizens and Property
2014	Incendiary devices	Palestine	Khirbat Abu Falah	Israeli settlers	0	0	Private Citizens and Property
2014	Acid and a screwdriver	Palestine	Betar Illit	Palestinian Extremists	0	6	Private Citizens and Property
2015	Chlorine gas	Iraq	Hit	Al-Naqshabandiya Army	36	Unknown	Private Citizens and Property
2015	Chlorine gas	Iraq	Kuwayr	Islamic State of Iraq and the Levant (ISIL)	0	0	Unknown
2015	Chloric acid	Iraq	Al-Baghdadi	Islamic State of Iraq and the Levant (ISIL)	3	0	Private Citizens and Property
2015	Chlorine-filled rockets	Iraq	Makhmur district	Islamic State of Iraq and the Levant (ISIL)	0	Unknown	Military
2015	Fired chemical-laced rockets	Syria	Marea	Islamic State of Iraq and the Levant (ISIL)	0	24	Private Citizens and Property
2015	Fired chemical-laced rockets	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	1	Military
2015	Tear gas	Israel	Jerusalem	Israeli extremists	0	1	Private Citizens and Property
2015	An explosives-laden and chlorine-laced tank	Iraq	Al-Fhilat	Islamic State of Iraq and the Levant (ISIL)	Unknown	Unknown	Military
2016	Tear gas	Palestine	Beitillu	Israeli extremists	0	0	Private Citizens and Property
2016	Chlorine gas	Iraq	Tharthar	Islamic State of Iraq and the Levant (ISIL)	72	66	Military
2016	Fired chemical-laced rockets	Iraq	Sinjar	Islamic State of Iraq and the Levant (ISIL)	0	40	Military, Private Citizens, and Property
2016	Mustard gas	Iraq	Taza Khurmatu	Islamic State of Iraq and the Levant (ISIL)	3	1500	Private Citizens and Property
2016	Fired chemical-laced rockets	Iraq	Taza Khurmatu	Islamic State of Iraq and the Levant (ISIL)	0	0	Private Citizens and Property
2016	Chlorine-laced and explosives-laden vehicles	Iraq	Nasr	Unknown	0	0	Unknown
2016	Fired chemical-laced rockets	Iraq	Bashir	Islamic State of Iraq and the Levant (ISIL)	18	10	Private Citizens and Property
2016	Fired chemical-laced rockets	Syria	Aleppo	Ahrar al-Sham, Free Syrian Army, Jaysh al-Islam (Syria)	9	29	Private Citizens and Property
2016	Explosives and chlorine gas	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	15	Military

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Table 1. (*Continued*)

Date	CBRN Weapon	Country	City	Perpetrator group	Death	Injury	Target types
2016	Chemical-laced mortar shells	Iraq	Hamdaniyah district	Islamic State of Iraq and the Levant (ISIL)	Unknown	Unknown	Military
2016	Fired chemical-laced rockets	Iraq	Bashir	Islamic State of Iraq and the Levant (ISIL)	0	8	Private Citizens and Property; Terrorists/Non-state Militia
2016	Fired chemical-laced rockets	Iraq	Bashir	Islamic State of Iraq and the Levant (ISIL)	0	40	Military, Private Citizens, and Property; Terrorists/Non-state Militia
2016	Fired chemical-laced rockets	Iraq	Bashir	Islamic State of Iraq and the Levant (ISIL)	0	4	Private Citizens and Property; Terrorists/Non-state Militia
2016	Nitric acid	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	25	0	Private Citizens and Property
2016	Fired chlorine-laced rockets	Iraq	Kahrez	Islamic State of Iraq and the Levant (ISIL)	0	35	Private Citizens and Property
2016	Unknown	Israel	Jerusalem	Palestinian Extremists	0	0	Transportation
2016	Fired chemical-laced rockets	Syria	Aleppo	Nur-al-Din al-Zinki Movement	7	20	Private Citizens and Property
2016	Fired chemical-laced rockets	Syria	Marea	Islamic State of Iraq and the Levant (ISIL)	0	5	Private Citizens and Property
2016	Fired chlorine-laced rockets	Iraq	Qayyarah	Islamic State of Iraq and the Levant (ISIL)	0	0	Military, Private Citizens, and Property
2016	Fired chemical-laced rockets	Iraq	Qayyarah	Islamic State of Iraq and the Levant (ISIL)	0	0	Military
2016	Fired chemical-laced rockets	Iraq	Qayyarah	Islamic State of Iraq and the Levant (ISIL)	0	0	Private Citizens and Property
2016	Chlorine gas	Iraq	Hatra	Islamic State of Iraq and the Levant (ISIL)	Unknown	Unknown	Private Citizens and Property
2016	Fired chemical-laced mortars	Syria	Aleppo	Ahrar al-Sham,Al-Nusrah Front	0	35	Military, Private Citizens, and Property
2016	Fired chemical-laced rockets	Syria	Aleppo	Ansar al-Din Front, Authenticity, and Development Front	2	29	Private Citizens and Property
2016	Fired chemical-laced rockets	Syria	Aleppo	Free Syrian Army	2	24	Private Citizens and Property
2016	Fired chlorine-laced mortar shells	Iraq	Khanukah	Islamic State of Iraq and the Levant (ISIL)	3	2	Private Citizens and Property
2016	Fired rockets containing mustard gas	Iraq	Qayyarah	Islamic State of Iraq and the Levant (ISIL)	Unknown	Unknown	Private Citizens and Property
2016	Fired rockets containing mustard gas	Iraq	Qayyarah	Islamic State of Iraq and the Levant (ISIL)	Unknown	Unknown	Private Citizens and Property
2016	Fired rockets containing mustard gas	Iraq	Qayyarah	Islamic State of Iraq and the Levant (ISIL)	Unknown	Unknown	Private Citizens and Property
2017	Poisoned food	Yemen	Sanaa	Houthi extremists (Ansar Allah) (suspected)	1	1	Journalists and Media
2017	Fired chemical-laced rockets	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	1	1	Private Citizens and Property
2017	Fired chemical-laced rockets	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	2	Private Citizens and Property
2017	Fired chemical-laced rockets	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	1	Private Citizens and Property
2017	Fired chemical-laced rockets	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	Unknown	Private Citizens and Property
2017	Fired chemical-laced rockets	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	Unknown	Private Citizens and Property
2017	Fired chemical-laced rockets	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	Unknown	Private Citizens and Property
2017	Fired chlorine-laced mortars	Iraq	Mubarak al-Farhan	Islamic State of Iraq and the Levant (ISIL)	Unknown	Unknown	Police, Private Citizens, and Property
2017	Fired chemical-laced rockets	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	6	29	Private Citizens and Property
2017	Explosives-and-chemical-laden drones	Iraq	Tal Afar	Unknown	0	0	Unknown

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Table 1. (*Continued*)

Date	CBRN Weapon	Country	City	Perpetrator group	Death	Injury	Target types
2017	Fired chemical-laced rockets	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	4	6	Private Citizens and Property
2017	Fired chlorine-laced shells	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	7	Military
2017	Fired chemical-laced rockets	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	0	Military
2017	Fired chemical-laced rockets	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	6	Military
2017	Fired chlorine-laced mortar	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	5	0	Military, Private Citizens, and Property
2017	Fired mortars containing poison gas	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	1	14	Police
2017	Fired chemical-laced mortars	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	13	Private Citizens and Property
2018	Fired chemical-laced mortars	Iraq	Mosul	Islamic State of Iraq and the Levant (ISIL)	0	3	Military
2018	Poisoned food	Iran	Mirjaveh	Jaish al-Adl	Unknown	Unknown	Police, Military, Terrorists/ Non-state Militia
2018	Fired chemical-laced rockets	Syria	Aleppo	Hay'at Tahrir al-Sham (suspected)	0	11	Private Citizens and Property
2018	Fired chemical-laced rockets	Syria	Aleppo	Hay'at Tahrir al-Sham (suspected)	0	11	Private Citizens and Property
2018	Fired chemical-laced rockets	Syria	Aleppo	Hay'at Tahrir al-Sham (suspected)	0	10	Private Citizens and Property
2019	Poisoned food	Iraq	Nasiriyah	Unknown	0	0	Religious Figures/Institutions
2019	Unknown	Tunisia	Tunis	Muslim extremists	0	0	Journalists and Media; Private Citizens and Property
2019	Fired chemical-laced rockets	Syria	Raseef	Unknown	0	21	Private Citizens and Property
2020	Unknown	Yemen	Altaweelah	Houthi extremists (Ansar Allah)	Unknown	Unknown	Private Citizens and Property
2020	Tear gas	Palestine	Unknown	Israeli settlers	0	0	Private Citizens and Property
2020	Poisoned food	Iraq	Hillah	Unknown	3.32	4.62745098	Private Citizens and Property

Table 2. Number of CBRN incidents in the middle east countries

Country	Number of incidents
Iraq	57 (68.67%)
Syria	13 (15.66%)
Palestine	6 (7.23%)
Israel	3 (3.61%)
Yemen	2 (2.41%)
Iran	1 (1.20%)
Tunisia	1 (1.20%)
Grand Total	**100.00%**

contributing 2 (2.41%), 1 (1.20%), and 1 (1.20%) respectively to the total count (Table 2).

It is worth noting that the countries with the most incidents—Iraq and Syria—are those that have seen significant conflict during this period, which may suggest a correlation between political instability or warfare and the prevalence of CBRN incidents. An analysis of the type of weapons used reveals that chemical weapons were the most employed, often in the form of fired, chemical-laced rockets. These accounted for 35.71% of incidents. Chlorine gas was used in 11.90% of the incidents. Alarmingly, in 9.52% of incidents, the type of weapon used was unknown, and this indicated potential gaps in detection or documentation efforts. Other notable weapon types include poisoned food (5.95%), explosives combined with chlorine gas (4.76%), and fired rockets containing mustard gas (3.57%).

The list also includes some more unconventional types of attacks, such as acid combined with a screwdriver, which demonstrates the breadth of methods used in CBRN incidents in some settings. This emphasizes the complexity and breadth of threats posed by CBRN weapons, requiring extensive planning, readiness, and countermeasures. Table 3 presents these findings in greater detail, illustrating the array of agents used during the period under study. This data highlights the critical need for robust and diverse countermeasures to tackle the wide range of CBRN threats. The MENA region's experience with these attacks underscores the urgency of understanding and addressing this global security issue.

Discussion

The present study offers a comprehensive analysis of CBRN incidents in the MENA region, shedding light on a disturbing pattern that spans from 2003 through 2020. Among the 84 incidents recorded, resulting in 205 deaths and 2205 injuries, chemical agents emerged as the primary weapon of choice, and

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Table 3. Type of agents used in MENA

CBRN Weapon	Count
Fired chemical-laced rockets	35.71%
Chlorine gas	11.90%
Unknown	9.52%
Poisoned food	5.95%
Explosives and chlorine gas	4.76%
Fired rockets containing mustard gas	3.57%
Fired chemical-laced mortars	3.57%
Tear gas	3.57%
Fired chlorine-laced rockets	2.38%
Incendiary devices	1.19%
Fired mortars containing poison gas	1.19%
Explosives-and-chemical-laden drones	1.19%
Chloric acid	1.19%
An explosives-laden and chlorine-laced tank	1.19%
Fired chlorine-laced shells	1.19%
Nitric acid	1.19%
Chlorine-laced and explosives-laden vehicles	1.19%
Chlorine-filled rockets	1.19%
Mustard gas	1.19%
Fired chlorine-laced mortar shells	1.19%
Fired chlorine-laced mortars	1.19%
Chemical-laced mortar shells	1.19%
Acid and a screwdriver	1.19%
A rocket loaded with unidentified chemical agents	1.19%
Fired chlorine-laced mortar	1.19%
Grand Total	**100.00%**

this result demonstrated a notable trend that aligns with global occurrences.

The alarming frequency of chemical attacks within the MENA region parallels other high-profile instances of chemical warfare across the world. For example, the Tokyo subway sarin attack in 1995 was 1 of the deadliest peacetime chemical incidents, causing more than 6000 victims.[12,13] This incident illustrated how easily accessible and deployable these chemical agents can be, and how devastating their effects are. In a similar vein, the repeated use of chemical weapons in the Syrian conflict underscores the persistence of this threat on a global scale.[14]

The study's findings highlight the acute public health impacts of chemical agents, which can cause symptoms ranging from drooling, vomiting, and diarrhoea to paralysis, asphyxiation, death, or long-term neurological damage.[15] These symptoms not only reveal the severity of chemical attacks but also underscore the urgency of a proper healthcare response. Healthcare preparedness and competent public health response including the use of antidotes, evacuation, and decontamination are vital to survival and can mean the difference between life and death.[16,17] Moreover, the risk of secondary toxicity due to inappropriate use of personal protective equipment by rescuers or family members are common.[15] This highlights an essential need for rigorous training and awareness among public health healthcare providers and first responders. Despite the development of recent evidence related to emergency care competencies in similar settings,[17–19] there seems to be a research gap concerning healthcare providers' competencies, particularly CBRN attacks, involving mass casualty scenarios.

Furthermore, the identification of various chemical weapons, leading to high morbidity and mortality, emphasizes a critical need for healthcare personnel to familiarize themselves with the categorization, clinical profiles, and management principles of these agents.[20] This extends beyond immediate response to encompass long-term care and psychological support for victims, as seen in the aftermath of chemical attacks in places like Halabja in Iraq and Ghouta in Syria.

Moreover, the findings of this study underline the multifaceted nature of the problem, encompassing not only the immediate medical response but also the wider societal, economic, and political implications of public health. Chemical attacks have the potential to disrupt entire communities, inflict long-lasting trauma, and undermine trust in public safety and governance.[21] This has been particularly evident in the MENA region, where political instability and ongoing conflict have further exacerbated the challenges posed by chemical weapons.

In response to our findings, it is imperative to integrate mental health services and community resilience programs into existing public health policies and emergency response strategies.[22] This integration not only addresses the immediate and long-term health impacts of CBRN incidents but also fosters a holistic approach to disaster preparedness. Strengthening psychosocial support systems, alongside physical health services,[23] will ensure a comprehensive response framework capable of addressing the full spectrum of needs arising from CBRN terrorism. Such measures are vital for building resilient communities that are better equipped to withstand and recover from these catastrophic events.

Other studies highlighted strategies that are applicable for emergency responders to maintain their security and safety in similar situations of armed conflict. This included preparing themselves holistically and ensuring their personal safety and the safety of others, maintaining a personal and family preparedness plan, identifying human behaviors that put individuals at risk, and identifying common human stress reactions.[17,24]

The situation calls for a comprehensive approach, including improved surveillance, enhanced preparedness, and supply streams at the healthcare level, as well as international cooperation to prevent the proliferation of these weapons. Health systems must develop robust strategies for immediate and long-term care, incorporating specialized treatment protocols, mental health support, and community-based rehabilitation services.[25]

Considering the study's primary focus on the prevalence and impact of CBRN incidents in the MENA region, it becomes imperative to elaborate on actionable strategies that can help mitigate these challenges. Central to the efforts in countering CBRN threats is the need for enhanced surveillance and early detection. Governments and international bodies should channel their resources towards acquiring state-of-the-art detection systems and technologies capable of quickly identifying and categorizing CBRN agents. Such advancements would not only expedite alerts to emergency services and the public but also facilitate more efficient evacuation and containment measures.

Yet, these technological advancements should be bolstered by strengthened international collaboration. The globalized nature of threats necessitates international partnerships, underscoring the importance of regular dialogues, intelligence sharing, and collaborative research. Such an approach would facilitate the development of unified strategies and preventative measures against CBRN incidents, transcending borders, and political differences.

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From a public healthcare perspective, the potential aftermath of CBRN events highlights the need for a continuous capacity-building approach. Healthcare providers should be subjected to ongoing training programs, emphasizing the identification, treatment, and long-term care of affected individuals.[26,27] Furthermore, this capacity building should encompass rigorous training sessions on the proper use of personal protective equipment and the management of mass casualty scenarios.

Parallel to these efforts, community awareness and preparedness cannot be overlooked. Governments, NGOs, and other stakeholders should spearhead public education campaigns, aiming to inform citizens about the inherent risks of CBRN incidents. These campaigns should be multifaceted, providing guidance on immediate actions during exposure, understanding shelter-in-place procedures, and even recognizing early signs of exposure.

In the realm of innovation, there's an unequivocal need to invest in research and development. This entails pushing for initiatives aiming to develop advanced antidotes, refine protective equipment, and establish effective decontamination methods. The spirit of collaboration should persist here, fostering environments conducive to innovative solutions that are both effective, and widely accessible.[28]

In a broader policy context, the onus falls upon governments to prioritize the formulation of all-encompassing policies that cater to the prevention, mitigation, and response to CBRN threats. Such an endeavor could involve enacting stricter regulations on the storage and transport of hazardous materials, coupled with a steadfast commitment to international conventions explicitly prohibiting the use of such weapons.[29,30]

On the often-overlooked psychological front, the traumatic nature of CBRN incidents necessitates the establishment of robust psychosocial support systems.[31,32] This should be realized in the form of therapy, counselling, and community-based rehabilitation programs; all designed to expedite the recovery process for victims and the broader community.

Lastly, as an outer line of defense, enhancing border and import controls is essential. By fortifying border checks and placing stringent controls on imports, especially those materials potentially utilized in CBRN weapon creation, nations can better secure their peripheries. This measure would greatly benefit from collaborating with neighboring countries, ideally establishing a harmonized system of checks and balances of health systems, staff, and supplies, as well as services.[33]

By weaving these strategies into the fabric of our defenses, the MENA region in harmony with global partners, can aspire towards a stance that's not just reactive but also proactive against the looming threat of CBRN terrorism. The roadmap laid out not only addresses immediate response imperatives but also charts a course towards the long-term vision of preventing such incidents and nurturing resilient communities.[34]

Limitations

The present study, despite its comprehensive analysis, has certain limitations. Primarily, the study's sole reliance on the GTD introduces potential biases or omissions. While GTD is a robust source, it may not capture all incidents and it may contain inaccuracies. A lack of cross-verification with other databases or primary sources could result in under or over-representations of certain incidents, affecting the findings' validity and generalizability.

By focusing on incidents from 2003 to 2020, the study omits data beyond this timeframe, possibly leading to a limited understanding of recent trends and developments. Such a temporal constraint might obscure emerging patterns or shifts in CBRN usage in the MENA region. The study also grapples with discrepancies in reporting or data collection across the MENA countries. Variations in government transparency, media freedom, and local data collection methods might introduce inconsistencies; further complicating the generalizability of the findings.

The unique nature of CBRN incidents also presents challenges. Such incidents might often be under-reported, misclassified, or concealed due to political sensitivities, and national security concerns, among others. This could result in an underestimation or misinterpretation of true incident patterns, affecting the perceived frequency and nature of CBRN attacks.

Although the study furnishes crucial quantitative data on CBRN incidents, it lacks qualitative insights. This omission restricts the exploration of the psychological and societal impacts, motives, ideologies, or broader human contexts surrounding these incidents. Furthermore, potential confounders like socio-political factors, cultural dynamics, and historical contexts that could influence CBRN incidents were not addressed. These overlooked elements might distort the interpretation of results, leading to a potentially skewed understanding of the factors driving CBRN attacks.

The study did not delve deeply into the secondary toxicity risks and the competencies of healthcare providers during mass CBRN incidents, which could offer vital insights into immediate post-incident scenarios. Future research should seek to address these limitations, encompassing multi-source data triangulation, an extended temporal range, and qualitative insights, as well as a deeper exploration of the contextual factors affecting CBRN incidents. Achieving a nuanced understanding of CBRN terrorism in the MENA region necessitates a more holistic approach to data gathering, analysis, and interpretation.

Conclusions

The findings of this research shed light on the pressing nature of CBRN threats in the MENA region, with a notable discovery of 84 CBRN incidents between 2003 and 2020, leading to 205 deaths and 2205 injuries. Predominantly, Iraq bore the brunt of these attacks, accounting for 68.67% of incidents, followed by Syria at 15.66%. This distribution underscores the heightened susceptibility of specific countries in the region to CBRN attacks.

A salient aspect of the data indicates that chemical agents were predominantly used in these incidents. This trend underscores a sombre reality: the sustained preference for chemical warfare as a tool of terror, causing profound distress both immediately and in the long term.

Beyond the immediate harm, the repercussions of these attacks manifest as prolonged health issues, an overwhelmed healthcare system, societal upheavals, and a diminished faith in governing entities.

The concentration of CBRN incidents in Iraq and Syria signals deeper socio-political, economic, and possibly historical issues; necessitating a more encompassing response than traditional counter-terrorism strategies. These findings emphasize the need for a cohesive, cross-sectoral strategy involving governments, medical institutions, and global agencies, as well as local communities. Such a holistic approach should address immediate prevention and response mechanisms, as well as invest in the sustained recovery, rehabilitation, and resilience of affected populations.

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This study also delineates areas warranting deeper exploration. This includes understanding the rationale behind selecting specific chemical agents, fortifying the expertise of healthcare providers in CBRN scenarios, and bolstering international cooperation for the enforcement of conventions against chemical weaponry. Implementing the insights from this study into pragmatic strategies, transformative solutions, and collective accountability is paramount.

In light of our findings, future research should delve deeper into the psychosocial dimensions of CBRN incidents, exploring the psychological resilience and societal adaptation in the aftermath of such events. This exploration is crucial for developing comprehensive disaster response strategies that address not only the physical but also the mental health needs of affected populations. Further studies on the long-term psychological impacts on survivors and healthcare providers, as well as community-based recovery models, are imperative to inform holistic public health preparedness and response frameworks.

In essence, this research accentuates the enduring menace of CBRN, especially chemical attacks, in the MENA region. It underscores the exigency for united, persistent, as well as informed measures to comprehend, and curtail/counter these challenges. This call to action reverberates beyond regional boundaries, emphasizing the global community's shared responsibility in combating terrorism. The pursuit to safeguard lives, uphold public safety, as well as reinforce global security remains an inclusive mission, and 1 that demands unwavering commitment, compassion, and sagacity.

Data availability statement. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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