



## GEOGRAPHIC PATTERNS AND STRATEGIC DISTRIBUTION OF SNAKEANTIVENOMS IN JORDAN'S MILITARY HOSPITALS

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### ABSTRACT

**1. Introduction:** Snakebite poisoning represents a considerable public health issue in Jordan, where *Viperapalaestinae*, or the Palestine viper, together with other venomous snakes, provides substantial hazards in multiple areas. These snakes thrive in various habitats, especially in regions with favorable ecological conditions. Bite management from *Viperapalaestinae* requires the use of a particular Saudi antivenom that effectively counteracts the venom's neurotoxic and hemotoxic properties. On the other hand, Indian antivenom is used for the poisoning of various snake species present in the area. The geographic and natural diversity in Jordan results in fluctuating snakebite hazards, constraining the distribution and accessibility of antivenoms to military hospitals within the Jordanian Royal Medical Services (JRMS). It is imperative to guarantee that hospitals in high-risk regions are adequately supplied with the necessary antivenoms to enable swift responses to snakebite incidents hence diminishing mortality and morbidity and improving patient outcomes.

**2. Objective:** This study aims to analyze the distribution patterns of Saudi and Indian antivenoms across four JRMS military hospitals (King Al-Hussein Military Hospital, Prince Rashid Ben Al-Hasan Military Hospital, Prince Ali Ben Al-Hussein Military Hospital, and Princess Haya Bent Al-Hussein Military Hospital) throughout 2020 to 2023. The study will seek to assess whether the existing allocation system corresponds with regional snakebite risks and seasonal demand fluctuations, with the ultimate goal of enhancing emergency preparedness and treatment effectiveness for envenomation incidents.

**3. Methodology:** The study will carry out a retrospective analysis employing JRMS antivenom distribution data obtained from JRMS main medical stores records system for the period of 2020 to 2023, distinguishing Saudi and Indian antivenom dispensation by hospital and year. Regional snake populations and reported high-risk seasons for snakebites will be investigated, with specific emphasis on geographic variations between northern regions of Jordan exhibiting a higher prevalence of *Viperapalaestinae* and southern regions where other snake species are more popular. Statistical analysis will be employed to recognize trends and correlations, providing recommendations for the optimization of antivenom stock allocations within JRMS facilities in order to meet the distinctive regional requirements.

**Keywords:**JRMS, antivenom distribution, *Viperapalaestinae*, snakebite management, Indian antivenom, Saudi antivenom, geographic-based stock, Jordan

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## 1. INTRODUCTION:

Snakebites pose a significant public health concern globally, especially in areas inhabited by venomous snake species. In Jordan, various venomous snake species contribute to health risks, particularly in rural and agricultural regions where human-snake interactions are frequent. *Viperapalaestinae*, commonly known as the Palestine viper, is among the most harmful venomous snakes indigenous to the area [1]. *Viperapalaestinae*, recognized for its potent venom, can induce serious and life-threatening symptoms, which include coagulopathy, hypotension, acute renal failure, and potentially death if left untreated [2,3]. Mitigating these health risks necessitates not only prompt medical action but also the provision of targeted antivenoms capable of neutralizing the venom effects specific for this snake species.

The Jordanian Royal Medical Services (JRMS), an established healthcare provider in Jordan, oversees the distribution of vital pharmaceuticals, including antivenoms, to military hospitals countrywide. This study examines the dispensing trends of two antivenom types, Saudi and Indian, supplied from JRMS main medical stores to four military hospitals in Jordan between 2020 and 2023. The Saudi antivenom is specifically effective against envenomation by *Viperapalaestinae*, but the Indian antivenom offers broad-spectrum treatment for bites from other venomous snakes in the region.

Considering that *Viperapalaestinae* presents a significant risk due to its unique venom composition [4], the Saudi antivenom, designed to counteract this species' venom, is essential in regions with increased viper populations. This study aims to examine the distribution patterns of Saudi and Indian antivenom in various hospitals, considering the geographic prevalence of *Viperapalaestinae* and other snake species in Jordan. This context facilitates enhanced understanding of resource allocation and the identification of regions with varying demand for different types of antivenom. Comprehending these trends can optimize antivenom distribution approaches, ultimately improving the ability of the country to address snakebite instances.

### Geographic and Environmental Context in Jordan:

The geographic diversity of Jordan encourages the heterogeneous distribution of snake species throughout the entire country. The nation's topography includes forested highlands in the

north, harsh deserts in the south, and green agricultural plains in the northwest. Each of these ecosystems sustains unique snake populations. The forested regions of Ajloun and the agricultural areas of Irbid in northern Jordan offers appropriate habitats for *Viperapalaestinae*, hence elevating the probability of snakebite occurrences. On the other hand, dry southern regions host other species, for which the Indian antivenom is frequently adequate [5,6].

The hospitals examined in this study are King Al-Hussein Military Hospital in Amman, Prince Rashid Ben Al-Hasan Military Hospital in Irbid, Prince Ali Ben Al-Hussein Military Hospital in Al-Karak, and Princess Haya Bent Al-Hussein Military Hospital in Ajloun. Each hospital is carefully positioned to provide medical care to communities exposed to varying environmental conditions and, thus, diverse snake species. Hospitals in Irbid and Ajloun, located near *Viperapalaestinae* habitats, may necessitate a greater supply of Saudi antivenom, whereas hospitals in southern regions such as Al-Karak may depend more on Indian antivenom for treating snakebites from non-*Viperapalaestinae* species [7].

### Importance of Antivenom Accessibility:

The efficacy of antivenom therapy depends not only on obtaining the appropriate type of antivenom but also on guaranteeing its prompt accessibility in critical areas. Antivenoms are specialized therapies, and their timely delivery is essential shortly after a snakebite to avert severe complications or death [1]. The JRMS's function in overseeing these supplies and allocating them to the military hospitals is crucial for public health and safety. Examining dispensing patterns and regional requirements can reveal differences or improvements that may enhance readiness and efficacy in snakebite treatment.

### Study Objectives:

This study seeks to evaluate the dispensing patterns of Indian and Saudi antivenoms at JRMS hospitals, investigating possible correlations with the geographic distribution of *Viperapalaestinae* and other venomous species in Jordan. This analysis aims to identify the demand patterns for each antivenom type from 2020 to 2023 and assess the alignment of JRMS's distribution strategy with regional requirements. This information may serve as a starting point for improving stock allocations, consequently guaranteeing that each region

possesses sufficient resources to successfully manage snakebite cases.

## 2. METHOD:

This retrospective study employs quantitative data regarding antivenom distribution sourced from the JRMS main medical stores. The dataset includes monthly average volumes of Saudi and Indian antivenoms distributed to four military hospitals in Jordan from 2020 to 2023. The four hospitals reviewed have locations in distinct geographic regions: King Al-Hussein Military Hospital in Amman (central Jordan), Prince Rashid Ben Al-Hasan Military Hospital in Irbid (northern Jordan), Prince Ali Ben Al-Hussein Military Hospital in Al-Karak (southern Jordan), and Princess Haya Bent Al-Hussein Military Hospital in Ajloun (northern Jordan).

The monthly averages were calculated by dividing the annual total allocations for each antivenom by twelve, facilitating year-to-year comparisons. A trend analysis was performed to identify changes in antivenom demand, while a geographic assessment examined the alignment of allocations with snakebite risks related to *Viperapalaestinae* and other species, whose habitats are affected by regional ecology.

This research utilized statistical methods, which included correlation analysis, to investigate the potential relationships between the geographic locations of hospitals and the amounts of each antivenom distributed. Furthermore, trends in antivenom distribution over the three-year period were analyzed to identify potential changes in demand patterns.

## 3. RESULTS:

The investigation of monthly antivenom distribution patterns among the four hospitals from 2020 to 2023 indicates notable differences in the allocation of Saudi and Indian antivenoms, underscoring geographic and temporal trends that likely correspond to regional snakebite risks. In 2023, the monthly average distribution at King Al-Hussein Military Hospital in Amman consisted of 5 ampules of Indian antivenom and 3 ampules of Saudi antivenom. In 2022, there was a notable increase to 14 Indian and 4 Saudi ampules per month, suggesting either an enhanced preparedness response or a stock adjustment in anticipation of

higher demand. The hospital's distribution patterns demonstrate its central location, where snakebites may occur less frequently; however, a general supply of both types of antivenom is essential due to the diverse population served.

At Prince Rashid Ben Al-Hasan Military Hospital in Irbid, the northern location is associated with increased average allocations, specifically for Indian antivenom, with 9 ampules of Indian and 3 ampules of Saudi antivenom distributed monthly in 2023. In 2022, the hospital averaged 14 Indian and 2 Saudi ampules per month, whereas 2021 recorded a peak of 22 Indian ampules with no supply of Saudi antivenom. The data indicate that Indian antivenom is essential in northern Jordan due to the presence of various venomous snake species, highlighting the need for expanded treatment alternatives. The consistent availability of Saudi antivenom in recent years indicates a response to the threat posed by *Viperapalaestinae*, which is known to inhabit northern regions.

The Prince Ali Ben Al-Hussein Military Hospital in Al-Karak demonstrates a significantly reduced demand for antivenoms, with average monthly distributions of three Indian ampules in 2023 and no Saudi antivenom, suggesting a low risk of encounters with *Viperapalaestinae* in this southern region. The 2022 distribution increased to 5 Indian and 3 Saudi ampules per month, compared to 3 Indian ampules and no Saudi antivenom in 2021, highlighting the persistently low demand in Al-Karak. This pattern indicates a restricted requirement for Saudi antivenom in this region, likely attributable to the minimal occurrence of *Viperapalaestinae* and potentially fewer encounters with venomous snakes in general.

In 2023, Princess Haya Bent Al-Hussein Military Hospital in Ajloun, located in northern Jordan, received an average monthly allocation of 10 Indian and 3 Saudi ampules, reflecting the increased incidence of snakebites in the region. In 2022, the hospital's allocation consisted of 17 Indian and 1 Saudi ampule monthly, maintaining a relatively high level from 2021, which included 15 Indian and 2 Saudi ampules. This trend indicates a stable demand for antivenoms, especially Indian. The distribution of Saudi antivenom in Ajloun, although less extensive than that of India, indicates the prevalence of *Viperapalaestinae* and the necessity for focused treatment in regions with increased risk (Table 1).

**Table 1: Frequency and distribution of using antivenom per year**

	Average monthly quantity in 2023		Average monthly quantity in 2022		Average monthly quantity in 2021	
	Antisnake (Indian)	Antisnake (Saudi)	Antisnake (Indian)	Antisnake (Saudi)	Antisnake (Indian)	Antisnake (Saudi)
King Al-Hussein Military Hospital	5	3	14	4	13	0
Prince Rashid Ben Al-Hasan Military Hospital	9	3	14	2	22	0
Prince Ali Ben Al-Hussein Military Hospital	3	0	5	3	3	0
Princess Haya Bent Al-Hussein Military Hospital	10	3	17	1	15	2

The results indicate significant disparities among regions in antivenom distribution, with hospitals in the northern regions of Irbid and Ajloun receiving greater average monthly supplies, especially of Saudi antivenom, consistent with the known habitats of *Viperapalaestinae* [7,8]. The prevalence of Indian antivenom in hospitals highlights the necessity for diverse treatment options for various venomous species present in Jordan. Temporal trends indicate that specific years, including 2022, experienced heightened allocations in certain hospitals, potentially as a precautionary measure or in response to an increased incidence of reported snakebites. This fluctuation underscores the dynamic nature of antivenom distribution and the necessity of adjusting stock levels in accordance with regional snakebite patterns and associated risk levels. The findings highlight the need for a strategic allocation system that incorporates geographic and temporal factors to guarantee timely access to life-saving antivenoms in Jordan's military hospitals.

#### 4. DISCUSSION:

The examination of anti-snake venom distribution patterns in JRMS hospitals in Jordan indicates notable trends in the utilization of Indian and Saudi antivenoms. The observed trends are associated with the geographic characteristics and local snake populations in the vicinity of each hospital [7,9]. The findings indicate that optimizing antivenom distribution according to regional snakebite risks may improve the responsiveness of the Jordanian healthcare system to snakebite incidents, particularly those involving *Viperapalaestinae*.

**4.1 Geographic Influence on Antivenom Demand:** The data suggest that specific hospitals, especially in snake-prone areas such as Irbid and Ajloun, obtained greater quantities of antivenom supplies. The Princess Haya Bent Al-Hussein

Military Hospital in Ajloun, located in a forested northern region suitable for *Viperapalaestinae* habitat, has received a significant supply of both Indian and Saudi antivenoms. This is likely attributed to an increased risk of encounters with various snake species, including *Viperapalaestinae*. This targeted distribution addresses the necessity for Saudi antivenom in regions where *Viperapalaestinae* is common, ensuring that these areas possess the essential resources to manage potentially fatal envenomations. However, the Prince Ali Ben Al-Hussein Military Hospital in Al-Karak, positioned in a drier area with limited known habitats of *Viperapalaestinae*, obtained a reduced quantity of Saudi antivenom ampules. The reduced allocation corresponds with the understanding that *Viperapalaestinae* is encountered less frequently in arid southern regions [10]. This indicates that JRMS's distribution strategy is partially consistent with the established ecological patterns of *Viperapalaestinae* [7,10], providing hospitals with suitable antivenom types according to probable local snakebite instances.

**4.2 Reliance on Indian Antivenom Across All Hospitals:** The geographic distribution of *Viperapalaestinae* in Jordan is extensive [10]; however, Indian antivenom represented a larger share of the total antivenom inventory in all hospitals, suggesting a greater dependence on this general treatment. This trend may indicate the diversity of snake species in Jordan and the practical approach to manage various snakebite instances using standard antivenom. The bites from *Viperapalaestinae* require Saudi antivenom for effective treatment, whereas Indian antivenom is essential for addressing bites from other snake species, especially in regions with diverse ecosystems such as Ajloun and Irbid [7]. This distribution indicates a potential shortcoming in stock management practices, suggesting that a

more customized approach could enhance response times and treatment outcomes, especially in regions where *Viperapalaestinae* is common.

**4.3 Challenges in Balancing Antivenom Stocks:** This study identifies a primary challenge in maintaining a balanced inventory of Indian and Saudi antivenoms in hospitals, addressing both expected and unforeseen demand. The data indicate a strategic allocation of Saudi antivenom to hospitals in northern regions; however, the limited availability in certain areas may hinder effective responses to *Viperapalaestinae* envenomations. It is essential for each hospital to maintain sufficient stocks of antivenoms to address both common and rare snakebite incidents, due to the highly specific nature of these treatments. A further challenge is the dependence on centralized supply chains, with hospitals relying on JRMS's main medical stores for inventory replenishment. High-demand periods, particularly during peak snakebite seasons in spring and summer, can lead to exacerbated shortages due to delays in resupply, especially for hospitals located in geographically remote areas. A decentralized strategy, such as stockpiling reserves in areas identified as high-risk, may effectively mitigate these challenges by decreasing dependence on central warehouses and facilitating prompt access during emergencies.

**4.4 Implications for Future Antivenom Allocation Strategies:** This study's geographic analysis of antivenom distribution indicates that JRMS could be strengthened through a more data-driven, region-specific strategy for antivenom allocation. Hospitals in northern regions with high incidences of *Viperapalaestinae*, such as those in Ajloun and Irbid, would benefit from increased supplies of Saudi antivenom. In contrast, hospitals in the southern region, like Al-Karak, could focus on general-purpose Indian antivenom. Enhancing collaboration with local healthcare facilities to collect real-time data on snakebite incidents may improve the accuracy of antivenom allocation decisions. Integrating data on snakebite cases and outcomes would enable JRMS to adjust antivenom stocks dynamically according to regional demand patterns, with the potential for seasonal adjustments during high-risk periods.

**4.5 Recommendations for Optimizing Antivenom Distribution:** Several recommendations can be proposed to enhance the JRMS antivenom distribution system based on the findings. Implementing geographic-based stock adjustments could enhance readiness by allocating Saudi antivenom according to known habitats of

*Viperapalaestinae*, particularly in northern areas with forested or agricultural regions such as Ajloun and Irbid. Hospitals with a higher incidence of *Viperapalaestinae* bites would benefit from an increased supply of Saudi antivenom to effectively address specific envenomations. A seasonal stock reserve system may mitigate demand fluctuations by creating supplementary reserves during peak snakebite periods, particularly in high-risk areas. This strategy would facilitate prompt availability of antivenoms during spikes in snakebite occurrences, thereby reducing the risk of significant shortages. The implementation of a centralized reporting system for data collection and monitoring may improve stock management by enabling the tracking of real-time snakebite data from hospitals. This data can inform accurate forecasting and resource allocation, allowing JRMS to adjust its distribution strategy in response to emerging trends. Decentralized storage in high-risk areas or emergency reserves in mobile units for remote hospitals can enhance accessibility, especially in regions where geographic distance or logistical delays pose challenges. Education and training programs for healthcare providers on the recognition and treatment of *Viperapalaestinae* bites using Saudi antivenom could improve response effectiveness, facilitating quicker and more informed actions in areas with elevated snakebite risks.

**4.6 Broader Implications for Public Health and Policy:** The findings of the study have significant implications for public health policy in Jordan concerning snakebite management. Efficient distribution of antivenom may decrease the morbidity and mortality linked to snakebites, especially in rural and underserved regions. Additionally, the development of a more resilient and responsive antivenom distribution system may provide a framework for other areas encountering comparable issues with venomous snake populations. Utilizing a data-driven approach to optimize antivenom allocations could enhance JRMS's preparedness for venomous snakebite incidents, thereby improving patient outcomes and resource efficiency.

## 5. CONCLUSIONS:

The findings indicate that JRMS's distribution of Saudi and Indian antivenoms is partially consistent with the geographic risk factors related to venomous species in Jordan. Hospitals in higher-risk areas such as Irbid and Ajloun received Saudi antivenom specifically for treating *Viperapalaestinae* bites, while the widespread

distribution of Indian antivenom indicates a comprehensive approach to addressing snakebite incidents across various regions. Enhancing emergency preparedness through adjusting the method of distribution according to local demand and seasonality would allow JRMS to improve the efficacy of treatments for snakebite envenomation.

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**Limitations of the Study:** The study is constrained by the lack of real-time data on snakebite incidents categorized by species, which would provide additional insights into hospital-specific requirements. Future research utilizing case data and patient outcomes may yield more accurate guidelines for regional antivenom stockpiling.

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