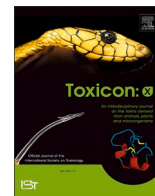


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Editorial

Special issue editorial: Resource mapping for the management of snakebite envenomation



The World Health Assembly adopted, in May 2018, a resolution urging state members to implement renewed and effective policies to reduce the burden of snakebite envenoming on a global basis (<https://www.who.int/news/item/25-05-2018-snakebite-envenoming-member-states-provide-who-with-clear-mandate-for-global-action>). Subsequently, in 2019, the World Health Organization (WHO) issued the first global strategy for the prevention and control of snakebite envenoming, aimed at halving, by the year 2030, the number of deaths and disabilities caused by these envenomings (WHO, 2019). The WHO strategy for snakebite envenoming is based on four main pillars: (1) empower and engage communities; (2) ensure safe, effective treatments; (3) strengthen health systems; and (4) increase partnerships, coordination and resources (WHO, 2019). These public health and political breakthroughs have prompted a diverse set of national and regional initiatives, with the participation of stakeholders of various sorts.

Ensuring the provision of safe and effective treatments for envenomings is a challenging task that involves actions at various levels, including research and development of antivenoms and novel therapies, an increase in the overall antivenom manufacturing capacity, strengthening the national regulatory agencies and programs aimed at ensuring the quality of antivenoms, improving the availability, affordability and accessibility of antivenoms, particularly at the rural health posts where the majority of snakebites occur, strengthening the public health systems and the provision of services, including technologies, drugs and diagnostic resources for treating envenomings, and reinforcing the training of health professionals in the diagnosis and clinical management of envenomings. Moreover, these tasks should be closely linked to associated actions at the community level and should be coordinated with local, regional, and national authorities.

The complexity of this scenario demands a comprehensive understanding of the various aspects involved in the supply network of antivenoms and other diagnostic and therapeutic tools, as well as on the human resources of the healthcare system and the engagement of the communities. This Special Issue of *Toxicon:X* brings together a series of contributions which address various aspects of this supply network in different settings and from diverse perspectives.

It is widely known that, in the Global South, a large proportion of people suffering snakebite envenomings first attend local traditional healers who, in many cases, constitute the only therapeutic resource available in remote rural communities. However, allopathic medicine has generally dismissed the role of traditional healers in handling envenomings and, consequently, there is usually limited communication between these parallel therapeutic approaches. Jonathan [Steinhorst et al. \(2022\)](#) explore this relevant topic and argue that patients can benefit from efforts aimed at integrating these two avenues. A

productive dialogue between allopathic practitioners and traditional healers is likely to bring benefits for the patients, and innovative approaches along this line should be promoted.

One of the four pillars of the WHO strategy to prevent and control snakebite envenoming is to empower and engage communities. In this Special Issue [Sakthivel Vaiyapuri et al. \(2023\)](#) describe and analyze several initiatives carried out in India and Brazil aimed at increased awareness on the problem of snakebites in communities in rural settings that bear a high incidence of envenomings. These initiatives have developed a variety of tools that provide information about the risk of snakebites and present the most effective actions to prevent and treat envenomings. These programs have also involved the training of health professionals in the correct diagnosis and treatment of envenomings, and efforts have been undertaken to engage these activities with the local authorities. In general, these initiatives rely strongly on the active participation and commitment of local communities in the design and implementation of the programs. The authors also discuss the need to evaluate the impact of these interventions, a challenging task indeed. The need to adapt these community-based programs to the local contexts is emphasized, as the experiences described in this work cannot be simplistically extrapolated to other settings.

Understanding the factors that enable or limit community engagement efforts in countries of high incidence of snakebites is a key aspect for fulfilling the WHO strategy to control and prevent these envenomings. [Noor Ten Have et al. \(2023\)](#), from the organization Health Action International, present the results of a qualitative study with key informants in India, Bangladesh and Nepal aimed at identifying key barriers and enablers of community engaging practices in these countries. The observations presented highlight aspects that provide valuable information on how to harness those factors that favor the success of these activities, and how to tackle aspects that limit the scope and impact of these interventions. Such lessons, together with those of other experiences in various contexts, are highly useful for improving the overall management of snakebite envenomings.

Australia has a long-standing tradition in the study of snake venoms, the development and production of high quality antivenoms, and the clinical management of envenomings. Nonetheless, there are issues related to delays in antivenom administration to patients due to pre-hospital and hospital factors, which are discussed by [Geoffrey Isbister \(2023\)](#). In the light of the potentially severe envenomings by Australian snakes, associated with neurotoxicity, myotoxicity, coagulopathy and acute kidney injury, there is a need to reduce the time interval between bite and treatment through innovative diagnostic tools and clinical management.

The limited availability and accessibility of safe and effective

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antivenoms for many countries in sub-Saharan Africa has been discussed over the years, and represents a central issue in the WHO global strategy to reduce the burden of snakebite envenoming. A WHO-led risk-benefit assessment of several antivenoms for Africa is being developed. In this Special Issue, Mahmood M. Dalhat et al. (2023) present an overview of antivenom availability, affordability, and accessibility in Africa, covering diverse aspects of this complex issue. The main bottlenecks operating upstream, midstream, and downstream are analyzed, involving aspects such as antivenom production and quality control, procurement policies, national regulatory agencies, models for antivenom distribution and use, training of health staff in the correct management of antivenoms, and governance. A multicomponent strategy is envisioned in order to leverage national, regional, and international resources, including the strengthening of the regional African capacities for research and development and production of antivenoms.

Mapping the clinical management resources to attend snakebite envenomings is a key aspect for understanding the situation of antivenom availability and accessibility in different countries, as well as to design more effective policies for ensuring a rapid attention to victims. In this Special Issue, antivenom availability in Costa Rica and Brazil is analyzed by Wendy Montoya-Vargas et al. (2022) and Timothy Beck et al. (2022), respectively. Both countries have a long tradition of efforts aimed at understanding and confronting this disease, including robust research communities on this topic, local antivenom manufacture, widespread antivenom provision, free of charge, by the public health system, and training of health staff in the diagnosis and treatment of envenomings. In the case of Brazil, after analyzing the situation at the macro, meso and micro levels of healthcare, the authors highlight current limitations in the Amazon region, where indigenous and riverine populations face important limitations for the rapid access to health centers where antivenom can be administered. This has to do with the limited number of hospitals having antivenoms, the long distances between the site of the bite and health facilities, with the consequent prolonged therapeutic journeys, the difficulties in providing rapid transportation, and cultural aspects that often limit access to medical care. The authors stress the need to improve the coverage of antivenom access through decentralization strategies. In the case of Costa Rica, Montoya-Vargas et al. (2022) present evidence of a widespread distribution of antivenoms in health facilities throughout the country, including primary health facilities, which has translated into a reduction in the time interval required for medical attention. At the same time, this study underscores limitations in the knowledge of Pharmacy professionals on several aspects of antivenom management, an issue that should prompt improvements in the coverage of this topic in university careers and in permanent education programs.

Comparative analyses between different countries on various aspects of snakebite envenoming and its management are sorely needed. Eleanor Strand et al. (2023) present a qualitative study, based on in-depth interviews and focus group methodologies, aimed at assessing the perceptions of healthcare providers in the USA and Brazil concerning various aspects of the management of snakebite envenomings. The study revealed common issues as well as differences between the two settings. The main themes that appeared from the analysis include barriers to adequate management of envenomings from the patient/community perspective and from the health system perspective, the perceived considerations on how to address these envenomings, and the identified needs for improving the management of cases. Notably, these two countries have different health systems, as Brazil has a universal public health care system whereas the USA has a mixed system including public and private branches. The needs that emerged from the analysis of these health systems showed differences, since participants from the USA identified the need for a universal standard of care, for government antivenom regulation and for insurance cost transparency, while participants from Brazil stressed the need to strengthen existing infrastructure to attend envenomings.

Julien Potet et al. (2023) present an overview of the vast experience

of Médecins sans Frontières (MSF) in the management of snakebite envenomings in various settings in Africa (Central African Republic, South Sudan and Ethiopia), where this organization has hospitals and other facilities. The study presents various standards of care, including the use of two types of antivenoms depending on the clinical syndromes of envenomings, i.e., neurotoxic or cytotoxic/hemotoxic. These antivenoms are provided free of charge in these health facilities. Other interventions, including surgical procedures, are also implemented in these settings. Moreover, the study describes efforts at improving community-based prevention activities and discusses further needs to improve the attention of snakebite victims.

Finally, Godpower Michael et al. (2022) present a review of the literature on a knowledge assessment of health professionals of Africa, Asia and the Middle East and knowledge gaps in several aspects related with the diagnosis and management of snakebite envenomings, including knowledge on the most important venomous snakes in their localities, on first aid interventions, and on the clinical management of envenomings. The study reveals important gaps in the knowledge of this public health topic and highlights several pressing needs related to the training of these professionals in order to improve their role in the management of these envenomings.

Overall, this collection of contributions highlights the complexity of the topic of therapeutic resources for snakebite envenoming, which includes, but goes well beyond, the need to have safe and effective antivenoms in health facilities. Additional multisectorial and interdisciplinary efforts should be undertaken to provide a more integrated perspective of this relevant subject, by including more geographical settings and contexts, and other topics, such as the resource mapping as related to envenomings in domestic animals. This information will be a valuable resource for making effective knowledge-based interventions aimed at fulfilling the goals of reducing the human suffering caused by snakebite envenoming.

Credit author statement

JMG prepared the first version of the manuscript. All authors reviewed and edited the manuscript.

Ethical statement

This is an editorial manuscript and therefore no specific ethical statement is required.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work described in this paper.

References

- Beck, T.P., Tupetz, A., Farias, A.S., Silva-Neto, A., Rocha, T., Smith, E.R., Murta, F., Dourado, F.S., Cardoso, D., Ramos, T.A., Sachett, A., Pinto, T.S., Pucca, M.B., Sampaio, V., Ramos, F., Vissoci, J.N., Sachett, J., Wehn, F.H., Staton, C.A., Gerardo, C.J., Monteiro, W., 2022. Mapping of clinical management resources for snakebites and other animal envenomings in the Brazilian Amazon. *Toxicon:X* 16, 100137.
- Dalhat, M.M., Potet, J., Mohammed, A., Chotun, N., Tesfahune, A., Haabib, A.G., 2023. Availability, accessibility and use of antivenom for snakebite envenomation in Africa with proposed strategy to overcome the limitations. *Toxicon:X* 18, 100152.
- Isbister, G.K., 2023. Antivenom availability, delays and use in Australia. *Toxicon:X* 17, 100145.
- Michael, G.C., Bala, A.A., Mohammed, M., 2022. Snakebite knowledge assessment and training of healthcare professionals in Asia, Africa, and the Middle East: a review. *Toxicon:X* 16, 100142.
- Montoya-Vargas, W., Gutiérrez, J.M., Quesada-Morúa, M.S., Morera-Huertas, J., Rojas, C., León-Salas, A., 2022. Preliminary assessment of antivenom availability and management in the public health system of Costa Rica: an analysis based on a survey to pharmacists in public health facilities. *Toxicon:X* 16, 100139.

- Potet, J., Singh, S., Ritmeijer, K., Sisay, K., Alcoba, G., Jouberton, F., Kinding, Y.W.H., Kruse, A., Bengaly, A., Sabino, M., Komar, N.P., Coldiron, M., 2023. Snakebite envenoming at MSF: a decade of clinical challenges and antivenom access issues. *Toxicon:X* 17, 100146.
- Steinhorst, J., Tianyi, F.L., Habib, A.G., Oluoch, G.O., Lalloo, D.G., Stienstra, Y., 2022. Uniting behind a common goal: collaboration between traditional healers and allopathic health care workers to improve rural snakebite care. *Toxicon:X* 16, 100140.
- Strand, E., Murta, F., Tupetz, A., Barcenas, L., Phillips, A., Farias, A.S., Santos, A.C., dos Santos Rocha, G., Staton, C.A., Ramos, F.R., Machado, V.A., Wen, F.H., Vissoci, J.N., Sachett, J., Monteiro, W., Gerardo, C.J., 2023. Perspectives on snakebite envenoming care needs across different sociocultural contexts and health systems: a comparative qualitative analysis among US and Brazilian health providers. *Toxicon:X* 17, 100143.
- Ten Have, N.J., Ooms, G.I., Waldmann, B., Reed, T., 2023. Barriers and enablers of community engagement practices for the prevention of snakebite envenoming in South Asia: a qualitative exploratory study. *Toxicon:X* 17, 100144.
- Vaiyapuri, S., Kadam, P., Chandrasekharuni, G., Oliveira, I.S., Senthilkumaran, S., Salim, A., Patel, K., Sachett, J.A.G., Pucca, M.B., 2023. Multifaceted community health education programs as powerful tools to mitigate snakebite-induced deaths, disabilities, and socioeconomic burden. *Toxicon:X* 17, 100147.
- World Health Organization, 2019. Snakebite Envenoming. A Strategy for Prevention and Control. World Health Organization, Geneva, p. 70.

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