A multicomponent strategy to improve the availability of antivenom for treating snakebite envenoming

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Abstract Snakebite envenoming is a common but neglected public health problem, particularly in impoverished rural regions of sub-Saharan Africa, Asia and Latin America. The only validated treatment for this condition is passive immunotherapy with safe and effective animal-derived antivenoms. However, there is a long-lasting crisis in the availability of these life-saving medications, particularly in sub-Saharan Africa and parts of Asia. We herein advocate a multicomponent strategy to substantially improve the availability of safe and effective antivenoms at the global level. This strategy is based on: (i) preparing validated collections of representative venom pools from the most medically dangerous snakes in high-risk regions of the world; (ii) strengthening the capacity of national antivenom manufacturing and quality control laboratories and their regulatory authorities and establishing new facilities in developing countries through technology transfer, as an integral part of efforts to develop their biological products industry; (iii) getting established laboratories to generate antivenoms for various regions of the world; and (iv) getting governments and relevant organizations to give snakebite envenoming due recognition within national and international public health policy frameworks. These ways of making antivenom available should be complemented by actions to improve health information systems, the accessibility of antivenoms, the training of medical and nursing staff, and community-based education. Such a multicomponent strategy involving stakeholders on many levels could help consolidate sustainable improvements in antivenom availability worldwide.

Abstracts in عربي, 中文, Français, Русский and Español at the end of each article.

Introduction

Envenoming following snakebite is a very common but globally neglected public health problem that primarily affects poor agrarian and pastoralist communities of Africa, Asia, Latin America and Oceania.[1–5] According to estimates, more than 5 million people in the world suffer snakebite every year. Of those who are bitten, approximately 125 000 die and around 400 000 are left with permanent sequelae.[2,3,6,7] However, more recent nationwide community-based surveys in Bangladesh and India have shown that the scale of this problem is far greater than suggested by hospital-based statistics[8,9] and that these global figures greatly underestimate the actual incidence of snakebite envenoming and the resulting mortality and disability.

An important factor that contributes to the morbidity and mortality associated with snakebites, particularly in sub-Saharan Africa and parts of Asia, is the poor availability of the only validated treatment for this disease: antivenoms.[2,3] Antivenoms are immunoglobulins, or immunoglobulin fragments, purified from the serum or plasma of animals hyperimmunized with snake venom. The basic technological platforms for antivenom manufacture are readily available in the public domain and the World Health Organization (WHO) has issued detailed guidelines for the production, quality control and regulation of snake antivenoms,[10] which have long been recognized as essential medicines. Our understanding of the key determinants of the quality and safety of antivenom manufacture continues to improve with advances in research and development strategies.[11] As a result, protocols for producing antivenoms with improved clinical effectiveness and safety are readily available. This makes snakebite envenoming one of the "tool-ready" diseases, unlike other neglected tropical diseases.[12] Nevertheless, in many regions of the world, the availability of effective and safe antivenoms remains abysmally poor.[1,3]

To substantially improve the availability of and access to effective and safe antivenoms, it is necessary to undertake coordinated efforts, at the national, regional and global levels, to tackle key aspects of antivenom production, financing, distribution and post-marketing surveillance, and to promote government policy engagement. Herein we propose a multicomponent strategy targeting several bottlenecks in global antivenom availability. Concerted attention to these proposals on the part of stakeholders working at different levels should result in substantial improvements in the production, coordinated supply and use of antivenoms worldwide. Although we focus on snake antivenoms, similar considerations generally apply to antivenoms for other types of envenomings, such as those induced by scorpions and spiders, and to antisera for use against important bacterial and viral infections, such as tetanus and rabies.[1]

The components of our proposed strategy are presented in the four sections that follow. A fifth section describes additional measures that can mitigate the morbidity and mortality associated with snakebite envenomings. The sixth and final section summarizes the advantages of the proposed strategy.

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Preparing validated, representative venom pools

For antivenoms to be fully effective, the venoms used in their manufacture must be representative of the toxin profiles of the snake species against whose venom effective neutralization is sought. Establishing captive collections of geographically representative populations of target species should be a priority both nationally and regionally. Epidemiological data should be combined with the taxonomic and venom proteomic profiles of snake populations to ensure that snakes of the appropriate species and geographic origin are collected, in accordance with national and international regulations. Snakes should be maintained under secure, environmentally appropriate, and hygienic conditions in well designed herpetaria (see *WHO guidelines for the production, control and regulation of snake antivenom immunoglobulins*[10] for specific recommendations on snake husbandry and venom collection and storage). Producing standard reference venoms calls for the establishment of strict standardized protocols for all aspects of venomous snake husbandry and venom collection, handling, stabilization, storage and quality control.[10] Traceability and quality control protocols are necessary to ensure that venoms are identifiable and retain their toxicological and biochemical properties. Using recombinant toxins to reinforce immunizing mixtures is possible in the case of venoms whose most important toxins have been identified.

An important use of representative snake venom pools, in addition to immunizing horses and other appropriate animal species to produce effective antivenom immunoglobulins, is in the preclinical assessment of the efficacy of these antivenoms. Carrying out independent in vitro or animal experiments to test the efficacy of antivenoms is a task belonging to national regulatory agencies and should be done routinely on a batch-by-batch basis, even if data on neutralizing potency have been provided by manufacturers seeking product registration.[13,14]

Strengthening manufacturing and quality control

The "universe" of antivenom manufacturing facilities is quite heterogeneous in its technological strengths, production capacities, infrastructure, equipment and staff qualifications.[15] Many laboratories, particularly in developing countries, belong to public institutions – ministries of health or universities – and target domestic needs. Some of these laboratories receive inadequate support from their institutions and require upgrading of their facilities, technology and staff training. Some antivenom manufacturers may collapse if not urgently strengthened. In Latin America, for example, antivenom manufacturing laboratories exist in Argentina, the Bolivarian Republic of Venezuela, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, Mexico, Peru and Uruguay.[10,16] Some of these are well established but others require upgrading. These laboratories can benefit from obvious opportunities for international collaboration, especially with more advanced groups within the region or overseas. Promising initiatives for regional cooperation aimed at improving national capacity for antivenom manufacturing have been undertaken.[15–17] These initiatives should be consolidated and supported by international agencies and nongovernmental organizations (NGOs) and by national health and science and technology authorities. This strategy should also be promoted in Asia, where existing antivenom manufacturing laboratories in countries such as Myanmar, Pakistan and Viet Nam are in desperate need of support to enhance their own capacities.

At the same time, some developing countries with established pharmaceutical and biotechnological facilities have local scientific expertise and professional manpower. This creates favourable conditions for transferring technology from laboratories with the skills and experience needed to establish local antivenom manufacture and quality control. This is under way in Sri Lanka,[18] where Animal Venom Research International (AVRI), an NGO from the United States of America with strong links to this Asian country, is supporting the development by Instituto Clodomiro Picado (of the University of Costa Rica) of a pilot batch of antivenom against the venoms of the most dangerous Sri Lankan snakes. The venoms were taken from snakes collected in Sri Lanka and maintained in a well-designed serpentarium supported by AVRI and by the local University of Peradeniya. Once this antivenom has been produced and preclinically tested, a clinical trial will be undertaken in Sri Lanka. If the new antivenom is demonstrated to be clinically effective and safe, a technology transfer agreement among AVRI, Instituto Clodomiro Picado and the Sri Lankan authorities is expected to establish sustainable local antivenom production. Similar arrangements involving experienced antivenom manufacturers and technology developers could be promoted in other Asian, African and Latin American countries. Successful international collaborations in the biopharmaceutical field, involving the so-called innovative developing countries, would encourage and provide useful guides for such projects.[19]

Generating antivenoms for international use

Countries such as Australia, Brazil, Costa Rica, Egypt, France, India, Mexico, South Africa and Thailand, have large, well established antivenom manufacturers.[10] Some have sufficient production capacity to manufacture a quota of antivenoms for other regions and countries. However, this plan requires the use of representative venom pools of proven quality from the countries where the antivenoms are to be used. In India, the use of geographically inappropriate venoms to produce antivenoms for export to other countries is a common but unacceptable practice.[14] The careful design of the immunizing venom mixtures through partnerships between research groups and manufacturers is a requirement of international collaborations, as in a proposal developed by the Global Snakebite Initiative to generate pan-African and pan-Asian antivenoms.[20]

Technical aspects of antivenom manufacture such as antivenom potency, formulation and presentation (e.g. liquid or freeze-dried and volume per vial) should be adapted to the needs of each country. Encouraging international initiatives for developing antivenoms for sub-Saharan Africa, a region with a crisis in antivenom availability and accessibility, are already being implemented.[1,21,22] An example is a project involving the Federal Ministry of Health of Nigeria, the Liverpool School of Tropical Medicine, the University of Oxford, Instituto Clodomiro Picado and the British antivenom producer Micropharm. Through this initiative, coordinated by the EchiTAb Study Group, safe and

effective antivenoms are generated by Micropharm and Instituto Clodomiro Picado for treating envenomings in Nigeria, particularly by the saw-scaled viper, *Echis ocellatus*.[23–26] After preclinical and clinical tests provided satisfactory results, the antivenoms were registered at the Federal Ministry of Health in Nigeria and are currently in clinical use in that country. Similar projects have resulted in the development of polyspecific antivenoms for sub-Saharan Africa by Instituto Bioclon in Mexico[27,28] and Instituto Butantan in Brazil,[29] and by manufacturers in France and South Africa. Elsewhere, a partnership among Instituto Clodomiro Picado, the University of Melbourne (Australia) and the University of Papua New Guinea resulted in the manufacture of a new monospecific antivenom for treating envenomings by the highly venomous taipan snake, *Oxyuranus scutellatus*, in Papua New Guinea.[30] This antivenom is currently being studied locally in a large randomized controlled trial with funding from Australia's National Health and Medical Research Council and Papua New Guinea's Office of Higher Education. The antivenom for the project conducted in Sri Lanka by Instituto Clodomiro Picado and AVRI would be produced locally after appropriate technology transfer and staff training. It is important to promote similar initiatives and partnerships using strategies tailored to the needs and technical capabilities of each country and project.

Health policy frameworks

Perhaps the biggest obstacle to enhanced and sustainable access to safe, effective antivenoms in the regions most in need of them is the critical lack of engagement of governments and national and international public health organizations. Even in some countries where snakebite is common in rural areas, ministries of health and local WHO representatives often seem reluctant to include snakebite and antivenom availability among their public health priorities. To establish the short- and long-term cost–benefits of antivenom supply strategies, a strong, evidence-based case needs to be developed. Increasingly, though, policy change at the government level needs to be driven not through foreign representations, but through the efforts of committed local advocates. Such a situation highlights the need for genuinely productive partnerships between different stakeholders.

A major step forward for developing economies would be the inclusion of antivenom manufacture in their industrial production of therapeutic biological products, such as human plasma-derived fractionated products (including essential hyperimmune and polyvalent immunoglobulins). In many respects, the production capabilities required for human plasma fractionation – i.e. plasma production, immunoglobulin purification, and viral inactivation technologies, production design, quality control and regulation[31,32] – can be used to establish state-of-the-art domestic production of antivenoms.

Another way to reverse the limited economy of scale that could raise the production costs of some antivenoms would be to boost communal investment in the production and supply of prequalified pan-African or pan-Asian antivenoms. The harsh reality is that Africa's rural poor cannot afford to pay up to 640 United States dollars (US$) for antivenom treatment (in sub-Saharan Africa, one vial of an effective antivenom might cost as much as US$ 200).[33] One way to effectively resolve this problem may be to have a collective of manufacturers with surplus capacity produce new antivenoms in bulk and in long-term quotas at predetermined prices using novel financial mechanisms. These can be product development partnerships of various types to generate the recurrent capital needed to meet the costs of research and development, clinical trials, and manufacturing and distribution. The results could be an antivenom costing as little as US$ 30 to 42 per vial, with the potential to avert nearly 820 000 disability adjusted life–years and 13 600 deaths per 100 000 treatments delivered (AntivenomAID, a product development partnership, unpublished data, 2012).

The involvement of international health organizations in efforts to produce safe, effective antivenoms locally or regionally is of paramount importance. WHO should promote awareness and help coordinate regional and global efforts in this area through regional training workshops and other activities to promote guidelines on antivenom manufacture and control[10] and through the inclusion of these topics on the agenda of WHO's Consultative Expert Working Group. Similarly, the success of the Global Alliance for Vaccines and Immunizations and other organizations (e.g. The Global Fund's Affordable Medicines Facility for Malaria) in developing dynamic funding mechanisms that allow vaccines and other medicines to reach those most in need should be taken as a model for improving antivenom availability. Members of the Global Snakebite Initiative have proposed establishing a mixed financial model to create an innovative pan-African polyvalent antivenom with improved safety and efficacy. Funding for basic research, development and stakeholder engagement would be sought from donor governments or grant-making organizations in industrialized countries; additional capital to fund sustainable production would be generated by beneficiary nations through investment in a private equity trust. This approach is similar to that followed by various international initiatives to develop new treatments for neglected tropical diseases and is clearly in line with several Millennium Development Goals.

Other mitigating measures

Although this paper focuses primarily on antivenom availability, other aspects need to be considered as part of an integrated strategy to reduce the effects of envenomings. These additional aspects, some of which have been analysed in previous publications,[2,3] include the following:

i) improving health information systems to generate reliable data on the incidence of envenomings as a basis for designing evidence-based programmes for antivenom distribution, as well as health staff and community education programmes to improve prevention. Community-based surveys are especially valuable in that they lack the statistical biases inherent in hospital-based surveys.[8,9]

ii) increasing access to antivenoms, particularly in rural areas, through mechanisms geared towards facilitating antivenom deployment, such as maintaining the cold chain (in the case of liquid antivenoms), sharing it with vaccination programmes, or improving coordination between rural health posts and central governmental offices. The clinical management of envenomings in primary-health-care facilities should be promoted.

iii) improving the use of antivenoms and reducing their wastage by training doctors and nurses in hospitals in their correct administration.[34] Proper training of medical staff requires national consensus on indications for antivenom treatment and the average initial dose. Regional guidelines have been published by WHO and are freely available on line, but only for the South-East Asia[35] and African regions[36]; no guideline is available for the American and Western Pacific regions, where snakebite is an important health problem. The clinical use of antivenoms can also be improved through rapid diagnostic tests. If the type of venom in a patient's blood could be quickly identified through such tests, snake antivenom could be administered earlier after a bite, with potentially superior clinical outcomes, and it would be possible to choose the correct antivenom among several products available.

iv) organizing the community to prevent snakebites and provide rapid and proper attention to snakebite victims by conducting culturally and geographically appropriate public education campaigns, and communicating with local traditional healers to avoid harmful or ineffective interventions and involve the community in getting people transported to health posts.[37]

Final considerations

In light of the shortage of antivenom in large areas of the developing world, the multicomponent strategy we are proposing would have several advantages. It would (i) exploit the strengths of various established and experienced groups around the world; (ii) engage countries currently unable to manufacture antivenoms themselves to generate representative venom pools and establish quality control protocols to test the preclinical efficacy of antivenoms; (iii) involve international foundations and NGOs devoted to public health in the types of international projects described above; (iv) generate a long-term inter-programmatic and intersectoral global effort involving multiple participants with diverse skills to ensure the sustained availability of antivenom; (v) improve engagement with government and foster better public health policy, as well as create long-term sustainable funding models to supply antivenoms at an affordable cost to those most in need; and (vi) combine skills and resources synergistically to make the production of antivenoms an essential part of the local manufacture and supply of biological products, given the presence of antivenoms on WHO's model list of essential medicines.[38]

In conclusion, efforts to increase the availability of snake antivenom should be linked with initiatives to make them more accessible too, as well as to improve health information systems, train doctors and nurses in their proper use, implement measures to prevent snakebite, and facilitate the appropriate management of snakebite victims. Such initiatives should be part of an integrated global strategy, as proposed in this paper, geared towards reducing the large morbidity and mortality associated with snakebite in many parts of the world. ■

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ملخص

استراتيجية متعددة المكونات لتحسين توافر مضادات السموم لعلاج التسمم الناجم عن لدغات الثعابين

التسمم الناجم عن لدغات الثعابين مشكلة شائعة في مجال الصحة العمومية ولكنها مهملة، لاسيما في المناطق الريفية الفقيرة في أفريقيا جنوب الصحراء الكبرى وآسيا وأمريكا اللاتينية. ويتمثل العلاج المعتمد الوحيد لهذه الحالة في العلاج المناعي السلبي بمضادات السموم الآمنة والناجعة المشتقة من الحيوان. ومع ذلك، ثمة أزمة طويلة الأجل في توافر هذه الأدوية المنقذة للأرواح، ولاسيما في أفريقيا جنوب الصحراء الكبرى ومناطق في آسيا. وندعو في هذه الوثيقة إلى استراتيجية متعددة المكونات لتحسين توافر مضادات السموم الآمنة والناجعة على الصعيد العالمي على نحو كبير. وتستند هذه الاستراتيجية على: (1) إعداد مجموعات معتمدة من مجمعات السموم التمثيلية من أخطر الثعابين طبياً في مناطق العالم شديدة التعرض للمخاطر؛ (2) تعزيز قدرات التصنيع الوطني لمضادات السموم ومعامل مراقبة الجودة وسلطاتها التنظيمية وإنشاء مرافق جديدة في البلدان النامية من خلال نقل التكنولوجيا، كجزء لا يتجزأ من الجهود الرامية إلى تطوير صناعة المنتجات البيولوجية؛ (3) إنشاء معامل لإنتاج مضادات السموم في المناطق المختلفة من العالم؛ (4) مطالبة الحكومات والمنظمات ذات الصلة بإيلاء التسمم الناجم عن لدغات الثعابين الاعتراف الواجب في أطر سياسة الصحة العمومية على الصعيدين الوطني والدولي. وينبغي استكمال وسائل توافر مضادات السموم هذه عن طريق إجراءات لتحسين نظم المعلومات الصحية وإتاحة مضادات السموم وتدريب الفريق الطبي والتمريضي والتثقيف المجتمعي. ومن الممكن أن تساعد هذه الاستراتيجية متعددة المكونات التي تشارك فيها الأطراف المعنية على عدة أصعدة في تعزيز التحسينات المستدامة في توافر مضادات السموم في أنحاء العالم.

摘要

改进治疗蛇咬伤毒化的抗蛇毒素可用性的多元战略

蛇咬伤毒化是一种常见但被忽视的公共卫生问题，在撒哈拉以南非洲、亚洲和拉丁美洲贫困的农村地区尤其如此。这种情况唯一经过验证的治疗是使用安全有效的动物抗蛇毒血清的被动免疫治疗。然而，尤其是在撒哈拉以南的非洲和亚洲部分地区，这种拯救生命的药物长期以来存在可获得性危机。我们这里提倡实

施多元策略，以在全球层面上大大提高安全有效的抗蛇毒血清的可获得性。这一战略基于：(i) 由世界高危地区大多数医学有意义危险性的蛇类，建立经验证的代表性系列蛇毒库；(ii) 在发展中国家，加强国家抗蛇毒血清的生产和质量控制实验室及其监管机构的能力，并通过技术转让建立新的设施，将其作为发展其生物制品行业工作的有机组成部分；(iii) 让成熟的实验室为世界不同地区生成抗蛇毒血清；(iv) 让政府和相关组织在国家和国际公共卫生政策框架内对蛇咬伤毒化给予应有的重视。这些提供抗蛇毒素来源的方法必须辅以行动，以改进健康信息系统、抗蛇毒素可及性、医疗和护理人员培训以及基于社区的教育。这种涉及多层面利益相关者的多元战略可能有助于巩固全球抗蛇毒素可获得性的可持续改进。

Résumé

Une stratégie à composants multiples pour améliorer la disponibilité des antivenimeux dans le traitement des envenimations par morsure de serpent

L'envenimation par morsure de serpent est un problème de santé publique fréquent, mais négligé, en particulier dans les régions rurales pauvres de l'Afrique subsaharienne, de l'Asie et de l'Amérique latine. Le seul traitement validé pour soigner cet état est l'immunothérapie passive avec des sérums antivenimeux d'origine animale sûrs et efficaces. Cependant, une crise durable limite actuellement la disponibilité de ces médicaments vitaux, surtout en Afrique subsaharienne et dans certaines parties de l'Asie. Nous préconisons ici une stratégie à composants multiples pour améliorer considérablement la disponibilité des sérums antivenimeux sûrs et efficaces à l'échelle mondiale. Cette stratégie repose sur: (i) la préparation de collections validées de groupes représentatifs de venins prélevés sur les serpents les plus dangereux sur le plan médical dans les régions à haut risque du monde; (ii) le renforcement de la capacité de production nationale des sérums antivenimeux, des laboratoires de contrôle qualité et de leurs organismes de réglementation, et la création de nouvelles installations dans les pays en développement par transfert de technologies, en tant que partie intégrante de la stratégie de développement de leur industrie de produits biologiques; (iii) la production par les laboratoires déjà établis de sérums antivenimeux pour les différentes régions du monde; et (iv) la reconnaissance officielle par les gouvernements et les organisations compétentes de l'envenimation par morsure de serpent dans le cadre des politiques de santé publique nationales et internationales. Ces façons de rendre disponibles les sérums antivenimeux devraient être complétées par des actions visant à améliorer les systèmes d'informations sanitaires, l'accessibilité des sérums antivenimeux, la formation du personnel médical et infirmier et les programmes communautaires d'éducation. Une telle stratégie à composants multiples impliquant des acteurs à différents niveaux pourrait contribuer à consolider les améliorations durables en matière de disponibilité des sérums antivenimeux dans le monde entier.

Резюме

Многокомпонентная стратегия по улучшению доступности противоядия для лечения отравлений в результате змеиных укусов

Отравление в результате змеиного укуса — это широко распространенная, но игнорируемая проблема общественного здравоохранения, особенно в бедных сельских регионах Африки южнее Сахары, Азии и Латинской Америки. Единственным проверенным способом лечения этого состояния является пассивная иммунотерапия с использованием безопасных и эффективных противоядий животного происхождения. Тем не менее, особенно страны Африки южнее Сахары и некоторые части Азии испытывают продолжительный недостаток этих жизненно важных лекарственных средств. Авторы данной статьи выступают за многокомпонентную стратегию существенного повышения доступности безопасных и эффективных противоядий на глобальном уровне. Эта стратегия основана на: (i) подготовке в регионах высокого риска утвержденных накопленных запасов ядов змей, являющихся самыми опасными с медицинской точки зрения; (ii) укреплении потенциала отечественных производственных мощностей по выпуску противоядий, лабораторий контроля качества и их регулятивных органов, а также создании новых мощностей в развивающихся странах путем передачи технологий в качестве неотъемлемой части усилий по развитию промышленности по выпуску биологических продуктов в данных странах; (iii) учреждении лабораторий для выпуска противоядий для различных регионов мира и (iv) побуждении правительств и соответствующих организаций к соответствующему признанию важности учета отравления в результате змеиных укусов в рамках национальных и международных систем политики общественного здравоохранения. Эти способы обеспечения наличия противоядия следует дополнить действиями по улучшению информационных систем здравоохранения, доступности противоядий, обучения медицинского и сестринского персонала и образовательных программ на уровне общин. Такая многокомпонентная стратегия с привлечением заинтересованных сторон на разных уровнях может способствовать консолидации устойчивых улучшений в сфере доступности противоядия по всему миру.

Resumen

Una estrategia multicomponente para mejorar la disponibilidad del suero antiofídico para el tratamiento del envenenamiento por mordedura de serpiente

El envenenamiento por mordedura de serpiente es un problema de salud pública común pero desatendido, especialmente en las regiones rurales más pobres de África subsahariana, Asia y América Latina. El único tratamiento reconocido contra estas mordeduras es la inmunoterapia pasiva con sueros antiofídicos de origen animal seguros y eficaces. Sin embargo, la disponibilidad de estos medicamentos esenciales para salvar vidas lleva mucho tiempo en crisis, en particular en África subsahariana y en algunas zonas de Asia. En el presente documento, abogamos por

una estrategia multicomponente para mejorar de forma sustancial la disponibilidad de sueros antiofídicos seguros y eficaces en todo el mundo. La estrategia se basa en: (i) preparar colecciones reconocidas de sueros antiofídicos representativos de las serpientes más peligrosas en zonas de alto riesgo del mundo; (ii) reforzar la capacidad nacional de producción de sueros antiofídicos y la calidad de los laboratorios de control y sus autoridades normativas, así como crear instalaciones nuevas en los países en desarrollo por medio de la transferencia de tecnología como parte integral de los esfuerzos por desarrollar su industria de productos biológicos; (iii) conseguir que los laboratorios consolidados fabriquen sueros antiofídicos para varias regiones del mundo; y (iv) conseguir que los gobiernos y las organizaciones pertinentes otorguen al envenenamiento por mordedura de serpiente el reconocimiento debido dentro del marco de las políticas nacionales e internacionales de salud pública. Estas tareas dirigidas a facilitar el suero antiofídico deben complementarse con acciones para mejorar los sistemas de información sobre la salud, la accesibilidad de los antiofídicos, la formación del personal médico y de enfermería, y la educación comunitaria. Una estrategia multicomponente de ese tipo, que incluye a los interesados a varios niveles, podría ayudar a consolidar mejoras sostenibles en la disponibilidad de antiofídicos en todo el mundo.

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