

The role of non-governmental organisations in controlling rabies: the Global Alliance for Rabies Control, Partners for Rabies Prevention and the Blueprint for Rabies Prevention and Control

L.H. Nel^(1,2)

(1) Department of Microbiology and Plant Pathology, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa

(2) Global Alliance for Rabies Control, 529 Humboldt St Suite 1, Manhattan, Kansas 66502, United States of America

E-mail: louis.nel@rabiesalliance.org; louis.nel@up.ac.za

Summary

Rabies control worldwide has been inadequate and neglected for many decades, and the disease continues to predominantly affect poor communities in Africa and Asia. As a zoonosis for which the main reservoir and vector, the domestic dog (*Canis familiaris*), is an economically non-viable species, the absence of cross-sectoral cooperation has been a major factor in the lack of effective control efforts. A shift in global focus is required to concentrate on the fact that rabies has the highest case fatality ratio of all infectious human diseases and that it still affects human health more significantly than many other infectious diseases that are perceived to pose more significant risks. Equally necessary is an acknowledgement that rabies control is complex and that the task of creating and executing a strategic plan for the disease can be overwhelming for those governments in the developing world where dog rabies is most problematic. Non-profit organisations operate independently of governments and intergovernmental organisations and can play a dynamic role in inter-sectoral collaboration and the creation of approaches and strategies for the control of complex diseases such as rabies. In 2008, the Global Alliance for Rabies Control (GARC) established Partners for Rabies Prevention (PRP), a widely representative group of rabies stakeholders and experts, which endeavours to support public-private rabies control activities throughout the world. After a landscape analysis, the PRP proceeded to develop and launch the Blueprint for Rabies Prevention and Control (comprising the Blueprint for Canine Rabies Prevention and Control; the Blueprint for Fox Rabies Prevention and Control and the Rabies Surveillance Blueprint). Subsequently, the Stepwise Approach towards Rabies Elimination (SARE) was embedded into the Canine Rabies Blueprint. The SARE is a planning and self-assessment tool that countries can use to develop activities and monitor progress towards a national programme and strategy for sustainable rabies control and elimination. Each of the elements needed to execute the SARE-derived strategy is cross-linked to the Canine Rabies Blueprint, which provides the specific methods and tools required, supported by references and examples. Together, the Canine Rabies Blueprint and the SARE should be regarded as a novel and dynamic operational toolkit, and a resource that provides comprehensive information for the development and implementation of rabies control strategies, built entirely on the principles of 'One Health'.

Keywords

Canine Rabies Blueprint – Global Alliance for Rabies Control – Non-governmental organisations – One Health – Rabies – Stepwise Approach towards Rabies Elimination.

Introduction

Rabies is a classical zoonosis, known by humankind for many centuries, but in the modern world, it has become a prime example of a neglected tropical disease that mostly affects communities with inequitable healthcare (1).

The establishment of rabies cycles in dogs became a significant public health concern in Europe during the late 1700s, and through the 1800s and early 1900s. Although rabies was eliminated in the United Kingdom through movement restrictions on dogs and culling rather than vaccination (2), it is the revolutionary progress achieved in the development of rabies vaccines and subsequent vaccination campaigns that have led to the elimination of dog rabies (canine rabies) elsewhere. These territories included, among others, Western Europe, Japan and subsequently North America (3, 4). The successes in dog rabies control were followed, however, by another rabies problem, namely the widespread emergence of rabies in wildlife. Rabies cycles in red foxes (*Vulpes vulpes*) became epidemic in Europe, while raccoons (*Procyon lotor*), skunks (*Mephitis mephitis*), various fox species, coyotes (*Canis latrans*) and other wildlife species became important rabies reservoirs and vectors in North America (3, 5, 6). Advances in oral vaccines and vaccination strategies led to the elimination of fox rabies in several Western European countries, but wildlife rabies continues to expand in Eastern Europe, and persists in the United States of America (USA), even with extensive and costly oral vaccination efforts (7, 8).

While the early development of vaccines allowed for the control and elimination of dog rabies in Western Europe and the United Kingdom, the widespread introduction of European strains of dog rabies virus (RABV) to other parts of the world took place with colonisation and the disease spread rapidly in the 1900s (9, 10). Indeed, today it is dog rabies that poses the greatest threat to human health. Regions where dog rabies has been eliminated report almost no human rabies deaths, even in those countries where wildlife rabies is abundant. Meanwhile, dog rabies across Asia and Africa constitutes 95% of the estimated 59,000 annual human rabies deaths (11, 12).

Control of rabies and the role of non-governmental organisations

Even though rabies has been preventable by vaccination since the 19th century, it still causes more human deaths than any other zoonotic disease (13, 14). It is imperative, therefore, to consider the major factors that are likely to have contributed to the chronic neglect of this fatal disease.

As a zoonosis for which the main reservoir and vector, the domestic dog (*Canis familiaris*), is an economically non-viable species, the need for (and lack of) cross-sectoral cooperation in dealing with the disease has been well recognised in recent years (15). From a public health perspective, there appears to be a lack of appreciation of the public health cost and impact of rabies, and misdiagnosis is common. From the Agriculture or Veterinary Services point of view, dogs are not only economically non-viable, but in the areas where the impact of rabies is most significant across Asia and Africa, dogs are typically free-roaming and receive very little, if any, primary healthcare (16). In addition, rabies predominantly affects poor rural communities in areas where access to healthcare is limited, being complicated by substandard infrastructure and remote locations. Moreover, rabies, perhaps perceived as a historical disease, is viewed as less newsworthy than emerging diseases that may pose a more widespread pandemic threat. Such diseases have been shown to attract huge interventions (e.g. Ebola haemorrhagic fever, influenza, severe acute respiratory syndrome [SARS], etc.). Advocacy therefore needs to focus on the fact that rabies has the highest case fatality ratio of all infectious human diseases (17) and continues to affect human health more significantly than many other infectious diseases that are perceived to be of greater significance (11, 18).

The World Health Organization (WHO) recognises rabies as both a neglected disease and a notifiable disease. However, some countries in which rabies poses the most significant threat still do not regard it as a notifiable disease (19). In addition, the level at which rabies is reported to WHO and the World Organisation for Animal Health (OIE) is generally low and does not correlate with even the most conservative estimates of the disease's occurrence (20, 21).

Given the above, the unique role of non-governmental organisations (NGOs) in driving an agenda to address the recurrent neglect of rabies in the modern world, as well as in the execution of the 'One Health' paradigm on the global, regional and national levels, are discussed in this paper. Non-profit organisations operate independently of governments and intergovernmental organisations and should be well positioned to play a dynamic role in creating opportunities for inter-sectoral collaboration, and the creation of approaches and strategies for the control of complex diseases, such as rabies. The Alliance for Rabies Control was initially registered in Scotland in 2006 and subsequently expanded into the USA as the non-profit Global Alliance for Rabies Control (GARC) in 2007. The GARC, as the leading rabies non-profit organisation in the world, is committed to developing strategies to prevent human deaths from rabies and relieve the burden of rabies in other animals, especially dogs. The organisation was built around the need for an integrated One Health inter-sectoral partnership approach, and considered that such

partnerships should address the need for intervention at different levels of disease control, particularly at the global, regional, national and community levels.

World Rabies Day

In its foundation year in 2007, GARC launched a major initiative, namely World Rabies Day (WRD). Falling annually on 28 September (the anniversary of Louis Pasteur's death), WRD has been remarkably successful in promoting rabies initiatives across the world. For example, WHO, the Food and Agriculture Organization of the United Nations (FAO) and the OIE used WRD in 2013 as an opportunity to unite in their goal to eliminate human rabies and control the disease in animals (22). Indeed, since the inaugural event in 2007, participatory activities and the numbers of countries involved in subsequent annual WRD initiatives have increased consistently from year to year, clearly illustrating the need for such messages in communities across the world (23). The principal objective of WRD remains advocacy and its main achievement: the generation of widespread awareness of rabies and its true burden. An appreciation of the impact and burden of rabies, as well as a cost–benefit analysis of rabies control, is an important driver of rationalising and implementing comprehensive control and elimination programmes.

Partners for Rabies Prevention

In 2008, GARC established Partners for Rabies Prevention (PRP), a widely representative group of rabies stakeholders and experts, which endeavours to support leading public–private rabies control activities throughout the world. In essence, PRP provides a space for collective strategic thinking and the generation of ideas and plans by enlisting the diverse skills, experiences and capabilities of its global spectrum of partners. The PRP functions as the technical arm of the GARC, while also uniting and focusing the global rabies community on the common objective of dog rabies elimination (15, 16). Serving as the Secretariat and Convener of PRP, the GARC arranges annual meetings, each of which follows an agenda relevant to the prevailing dynamics, developments and needs in the rabies sector at that time. The list of delegates for each annual meeting, whether attending in a personal capacity or as representatives of key organisations, is compiled based on the specific agenda to be discussed. Partners for Rabies Prevention has thus typically included key representatives of: intergovernmental organisations such as the tripartite (FAO/OIE/WHO), academic institutions, foundations, NGOs, rabies vaccine manufacturers, WHO Collaborating Centres, OIE Reference Centres, rabies expert networks and the governments of rabies endemic countries. Many partners within PRP have

a long history of facilitating national efforts to control rabies, and their combined expertise in rabies control and other relevant fields has contributed to the creative and solution-orientated environment that has characterised PRP meetings. In order to accommodate the range of activities undertaken by PRP, partnership agreements are engaged in and vary in scale and focus from broad-based umbrella agreements focusing on global rabies elimination to technical agreements with sub-national authorities focusing on operational research. Formal collaborative agreements with multilateral organisations (FAO, OIE, WHO) support global coordination and elimination plans. The addition of representatives of foundations (e.g. UBS Optimus Foundation, Bill and Melinda Gates Foundation) and rabies vaccine manufacturers (e.g. Sanofi Pasteur, Novartis, Merck Animal Health, Merial, IDT Biologika, etc.) allowed PRP to benefit from global health insights, market data and corporate planning. Each year, a GARC/PRP meeting is scheduled, the ninth of which was held in 2017.

Blueprint for Canine Rabies Prevention and Control and the Stepwise Approach towards Rabies Elimination

In 2009, PRP set itself the task of identifying gaps in the rabies landscape and global rabies policy that were preventing progress in rabies control. Some of the key barriers identified were as follows:

1. a lack of data on the human and economic burden of the disease
2. the poor coordination of national and international efforts
3. a lack of awareness concerning the most appropriate and effective rabies control mechanisms
4. the limited availability of and capacity to deliver vaccines
5. too few successful demonstration projects
6. very limited engagement of key policy-makers in endemic countries (16).

This analysis formed the basis of the future strategy and planning of PRP. Key elements of this strategic process included the establishment of specific applied research priorities and advocacy efforts, and sought to address the traditional research–policy disconnect (24, 25). The resulting applied research plans addressed communication and education efforts, the challenges of limited inter-sectoral collaboration, and technical research questions. These questions included those on poor compliance with laboratory diagnosis and surveillance,

and the potential for new tools and methods that could address this shortcoming. Overall, an important element of this approach was the understanding that inter-sectoral stakeholder partnerships ranging from global to municipal levels were necessary to successfully tackle the challenges of rabies prevention.

It was also well understood that control programmes targeting the vaccination of dogs could effectively reduce the risk rabies poses to humans (15, 17). However, it is apparent that the design and implementation of such programmes still pose considerable challenges to local governments. Rabies is a complex disease and the components of programmes to control it are therefore equally multifaceted. These aspects should not be underestimated. Although rabies can be prevented in humans by effective pre- and post-exposure prophylaxis, the disease has to be controlled at the reservoir source in order to break the transmission cycle. Therefore, it is clear that the most cost-effective control measure to eliminate dog-mediated human rabies is the routine vaccination of dogs, a realisation measure which epitomises the concept of a One-Health approach to disease control (26, 27, 15). However, the lack of any guidelines, beyond the concept of adequate vaccination coverage of dogs (to provide herd immunity and stop the transmission of RABV in the dog reservoir), has been identified as an important contributor to the ineffectiveness of rabies control in the dog-rabies-endemic world.

Given this background, PRP thus developed and launched the Blueprint for Rabies Prevention and Control, in a quest to meaningfully assist in potential or existing national and international rabies interventions (www.rabiesblueprint.org). This Blueprint, built in its entirety on the principles of the One Health concept, should be regarded as a novel and dynamic operational toolkit, and a resource that provides comprehensive information for the development and implementation of rabies control strategies aimed at the disease's elimination (28).

There are three components of the Rabies Blueprint:

1. Blueprint for Canine Rabies Prevention and Control
2. Blueprint for Fox Rabies Prevention and Control
3. the Rabies Surveillance Blueprint (applicable to any host species).

These components are freely available online and are regularly updated. At the end of 2014, the Stepwise Approach towards Rabies Elimination (SARE) was added to and embedded in the Canine Rabies Blueprint. The SARE is a planning and self-assessment tool that countries may use to develop activities and monitor progress towards a national programme and strategy for sustainable rabies prevention, control and eventual elimination, focusing

on the prevention of dog-mediated human rabies. The Approach was first developed by FAO and the GARC in 2012, with the support of WHO and the OIE (29).

As discussed previously, the development of national rabies control strategies is often a daunting task and the SARE, together with the Canine Rabies Blueprint, has been designed to provide the most detailed guidance in this regard (30). In short, the Canine Rabies Blueprint/SARE tool provides countries with measurable steps to allow them to progress from Stage 0 to Stage 5 in the path towards becoming canine-rabies free (Fig. 1). Each stage of the SARE is characterised by a set of milestones and each of these milestones in turn is weighted towards a SARE score, providing a tangible status of progress, or lack thereof (31, 32). These stages can be summarised as follows:

Stage 0: Data non-existent; rabies is suspected to be present

Stage 1: Rabies epidemiology is assessed and a short-term rabies action plan is developed

Stage 2: A detailed national rabies prevention and control strategy is developed

Stage 3: Full-scale implementation of the national rabies control strategy

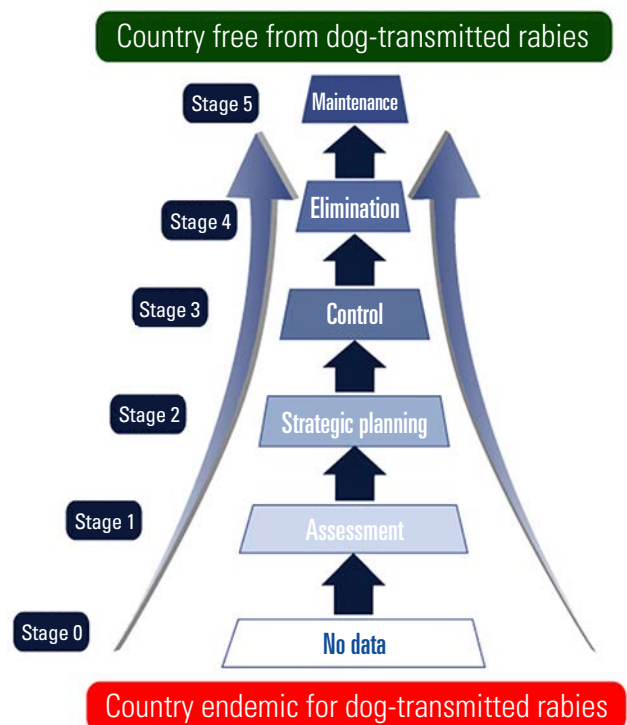
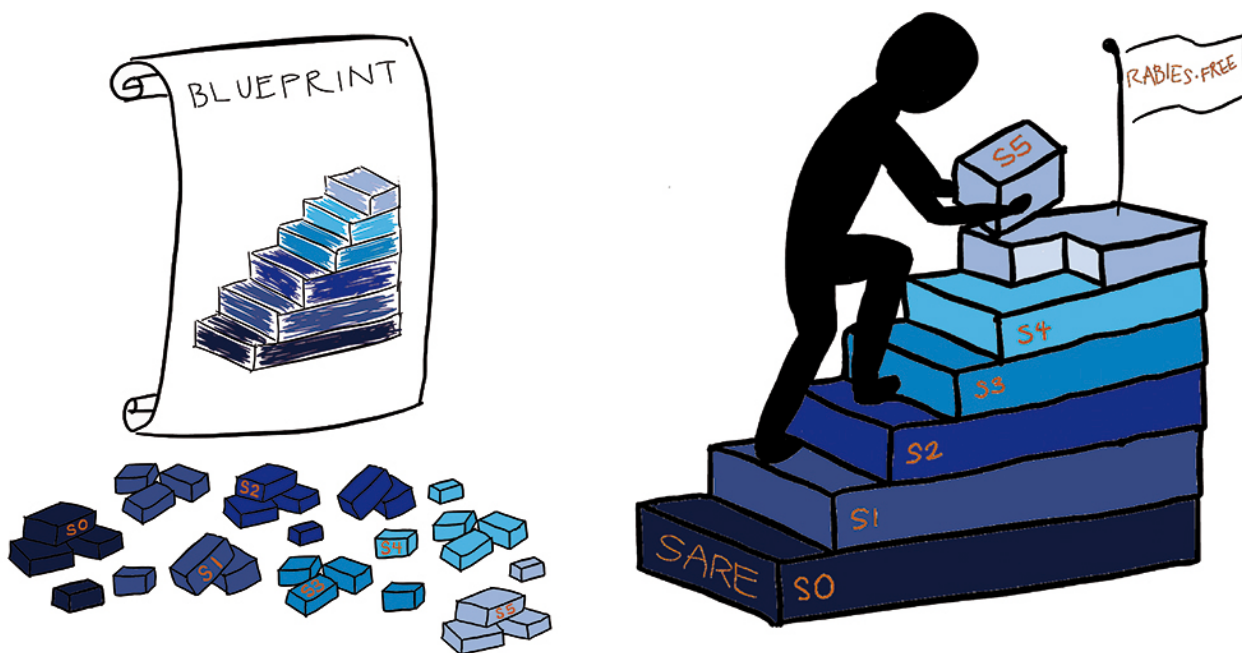


Fig. 1
Illustration of the six stages or steps of the Stepwise Approach towards Rabies Elimination (SARE)

Each step has been designed to contain measurable objectives and milestones



Blueprint: Blueprint for Canine Rabies Prevention and Control
 S0-5: stages 0 to 5
 SARE: Stepwise Approach towards Rabies Elimination

Fig. 2
Cross-linking between the Blueprint for Canine Rabies Prevention and Control and the Stepwise Approach towards Rabies Elimination (SARE)

Each of the elements needed for the execution of the SARE-derived strategy is cross-linked to the Blueprint for Canine Rabies Prevention and Control, providing the specific methods and tools necessary, supported by up-to-date references and examples

Stage 4: Maintenance of human rabies freedom, elimination of dog rabies

Stage 5: Freedom from human and dog-mediated rabies declared and monitored.

The Canine Rabies Blueprint/SARE tool is divided into seven main categories with each category providing detailed stage-specific activities that need to be addressed. Specific critical activities determine whether a country progresses to the next stage. As such, not all of the activities are mandatory for advancement, but they still provide clear guidelines with regard to elements that need to be addressed in order to control and eventually eliminate rabies. The categories are as follows:

1. Legislation: legislative requirements for rabies control and elimination
2. Data collection and analysis: the need for and elements of an effective surveillance network and epidemiological analyses of rabies
3. Laboratory diagnosis: the need for and elements of diagnostic capacity at both the national and regional levels

4. Information, education and communication: the need for advocacy and education, and the tools available for these initiatives and processes

5. Prevention and control: focuses on existing disease intervention strategies that are being implemented

6. Dog-population-related matters: focuses on all dog population-related questions (population size/turnover, etc.)

7. Cross-cutting issues: the need for collaboration between various stakeholders in the development of control strategies in both the planning and implementation phases.

Each of the elements needed for the execution of the SARE-derived strategy, is cross-linked to the Canine Rabies Blueprint, providing methods, guidelines, references and examples (Fig. 2). Critical factors considered include legislation, advocacy, education, details of human and animal vaccines and vaccination protocols, vaccination strategies, diagnosis and methodology, maintenance of surveillance and budgeting guidelines. Legislation, for example, is a prerequisite for the control of rabies. The need for surveillance, with diagnostic laboratory support and the reporting of data not only enables an understanding of disease burden and impact, but also assists in the

development of appropriately targeted control strategies. The performance of a cost–benefit analysis in which the expense of controlling rabies is weighed against the cost of vaccinating and treating humans, and the other losses incurred while continuing to cope with the disease, is also important in the prioritisation of rabies control investment.

A recent model has been designed to project the resources that would be required for canine rabies vaccination (e.g. vaccines, vaccinator resources and funds) (33). The model

considers mass vaccination efforts aimed at the elimination of dog-mediated human rabies by 2030 and incorporates components such as the current development index of a country, the cost of dog vaccination, the availability of vaccine, and the availability of the human resources to perform the animal vaccinations. Efforts are under way to integrate this and other helpful tools and models into the Canine Rabies Blueprint/SARE tool. ■

Le rôle des organisations non gouvernementales dans la lutte contre la rage : l'Alliance mondiale contre la rage, Partners for Rabies Prevention et le Plan directeur de prévention et de contrôle de la rage canine

L.H. Nel

Résumé

Cela fait des dizaines d'années que la rage est une maladie négligée et que les efforts consacrés à la combattre à l'échelle mondiale sont insuffisants ; la maladie continue donc à sévir en plusieurs endroits de la planète en affectant surtout les communautés pauvres d'Afrique et d'Asie. La rage est une zoonose dont le principal réservoir et vecteur, le chien domestique (*Canis familiaris*), est une espèce ne présentant pas d'enjeu économique de sorte que c'est surtout l'absence de coopération intersectorielle qui est la principale cause du manque d'efficacité des activités de lutte. Il faut faire évoluer ces efforts à l'échelle mondiale à partir du constat que la rage est de toutes les maladies infectieuses humaines celle qui a le taux de létalité le plus élevé et que son impact sur la santé humaine reste supérieur à celui d'autres maladies infectieuses pourtant perçues comme présentant des risques plus significatifs. Il est tout aussi indispensable de prendre conscience du fait que la lutte contre la rage est une entreprise complexe et que la conception et l'exécution d'un plan stratégique contre cette maladie constituent des tâches écrasantes pour les gouvernements des pays en développement, où la rage canine pose le plus de problèmes. Les organisations à but non lucratif opérant indépendamment des gouvernements et des organisations intergouvernementales peuvent jouer un rôle pour dynamiser la collaboration intersectorielle et contribuer à la conception d'approches et de stratégies de lutte contre des maladies complexes telles que la rage. En 2008, l'Alliance mondiale contre la rage (GARC) a lancé l'initiative Partners for Rabies Prevention (PRP), un groupe formé d'un vaste éventail de parties prenantes et d'experts dans le domaine de la rage et ayant pour vocation de soutenir les activités relevant de partenariats public-privé pour lutter contre la rage partout dans le monde. Après une analyse globale de la situation, le partenariat a élaboré et mis en route le Plan directeur de prévention et de contrôle de la rage (doté de trois volets, à savoir les Plans directeurs pour la prévention et le contrôle de la rage canine et vulpine et le Plan directeur pour la surveillance de la rage). Par la suite, l'Approche raisonnée de l'élimination de la rage (SARE) a été intégrée au Plan directeur pour la prévention de la rage canine. SARE est un outil de

planificación et d'auto-évaluation mis à disposition des pays afin de les aider à concevoir leurs activités et à suivre les progrès enregistrés dans l'élaboration de leurs stratégies et programmes nationaux de lutte et d'élimination de la rage. Chaque élément opérationnel des stratégies élaborées sur la base de SARE est rattaché au Plan directeur pour la prévention et le contrôle de la rage canine, qui fournit les méthodes et les outils spécifiques nécessaires ainsi que des références et des exemples pertinents. Pris ensemble, le Plan directeur et SARE sont à envisager à la fois comme une boîte à outils opérationnelle innovante et dynamique et comme une base d'informations exhaustives pour l'élaboration et la mise en œuvre de stratégies de lutte contre la rage, entièrement conçues dans une perspective « Une seule santé ».

Mots-clés

Alliance mondiale contre la rage – Approche raisonnée de l'élimination de la rage – Organisation non gouvernementale – Plan directeur de prévention et de contrôle de la rage canine – Rage – Une seule santé.



Función de las organizaciones no gubernamentales en la lucha antirrábica: la Alianza Mundial de Lucha contra la Rabia, Partners for Rabies Prevention y el Plan maestro de prevención y control de la rabia

L.H. Nel

Resumen

La lucha antirrábica a escala mundial lleva muchos decenios de inadaptación y de relegación a un segundo plano, mientras la enfermedad sigue afectando principalmente a las comunidades pobres de África y Asia. Tratándose de una zoonosis cuyo principal reservorio y vector, el perro doméstico (*Canis familiaris*), es una especie económicamente inviable, la falta de cooperación intersectorial es uno de los principales factores que explican la ausencia de medidas de control eficaces. Es imperativo imprimir un giro a las líneas de trabajo mundiales para empezar a tener en cuenta que la rabia presenta la tasa de letalidad más alta de todas las enfermedades infecciosas del ser humano y que sigue afectando a la salud humana en mayor medida que otras muchas infecciones consideradas en cambio más peligrosas. También hay que tomar conciencia de que la lucha contra la rabia es compleja y de que los gobiernos de los países en desarrollo, donde la rabia es más problemática, a veces se ven superados por la titánica empresa de elaborar y aplicar un plan estratégico en la materia. Las organizaciones sin ánimo de lucro, que trabajan independientemente de gobiernos y organizaciones intergubernamentales, pueden cumplir una función dinámica de cara a la colaboración intersectorial y la creación de métodos y procedimientos de lucha contra enfermedades complejas como la rabia. Así, en 2008, la Alianza Mundial de Lucha contra la Rabia (GARC) estableció «Partners for Rabies Prevention» (PRP), amplio grupo representativo de los círculos de especialistas y otros interlocutores relacionados con la rabia que se dedica a respaldar en todo el mundo actividades de lucha antirrábica que federan a los sectores público y

privado. Tras un análisis de la situación general, PRP procedió a elaborar y poner en práctica el «Plan maestro [*Blueprint*] de prevención y control de la rabia» (que a su vez se declina en un plan maestro de prevención y control de la rabia canina; un plan maestro de prevención y control de la rabia vulpina; y un plan maestro de vigilancia antirrábica). Posteriormente, al plan maestro contra la rabia canina se le incorporó el «método progresivo para la eliminación de la rabia» (SARE, por sus siglas en inglés). El SARE es una herramienta de planificación y autoevaluación que los países pueden emplear para definir actividades y seguir de cerca la progresión hacia un programa y una estrategia nacionales de control y eliminación sostenibles de la rabia. Cada uno de los elementos necesarios para ejecutar la estrategia que se deriva del SARE guarda vínculos cruzados con el plan maestro contra la rabia canina, en el que se facilitan los métodos e instrumentos específicos necesarios, acompañados de referencias y ejemplos. El plan maestro contra la rabia canina y el SARE deben ser vistos conjuntamente como una novedosa y dinámica «caja de herramientas prácticas» y una fuente de información completa para definir y aplicar estrategias de lucha antirrábica, asentadas ambas por entero en los principios de «Una sola salud».

Palabras clave

Alianza Mundial de Lucha contra la Rabia – Método progresivo para la eliminación de la rabia – Organizaciones no gubernamentales – Plan maestro contra la rabia canina – Rabia – Una sola salud.



References

- World Health Organization (WHO) (2010). – Working to overcome the global impact of neglected tropical diseases: first WHO report on neglected tropical diseases. WHO, Geneva, Switzerland. Available at: http://apps.who.int/iris/bitstream/10665/44440/1/9789241564090_eng.pdf (accessed on 18 April 2018).
- Fooks A.R., Roberts D.H., Lynch M., Hersteinsson P. & Runolfsson H. (2004). – Chapter 3 – rabies in the United Kingdom, Ireland and Iceland. In Historical perspective of rabies in Europe and the Mediterranean Basin (A.A. King, A.R. Fooks, M. Aubert & A.I. Wandeler, eds). World Organisation for Animal Health (OIE), Paris, France, 25–32. Available at: www.oie.int/doc/ged/d11246.pdf (accessed on 18 April 2018).
- Wandeler A.I. (2008). – The rabies situation in Western Europe. *Dev. Biol. (Basel)*, **131**, 19–25.
- Taylor L.H. & Nel L.H. (2015). – Global epidemiology of canine rabies: past, present, and future prospects. *Vet. Med. Res. Reports*, **6**, 361–371. doi:10.2147/VMRR.S51147.
- Velasco-Villa A., Reeder S.A., Orciari L.A., Yager P.A., Franka R., Blanton J.D., Zuckero L., Hunt P., Oertli E.H., Robinson L.E. & Rupprecht C.E. (2008). – Enzootic rabies elimination from dogs and reemergence in wild terrestrial carnivores, United States. *Emerg. Infect. Dis.*, **14** (12), 1849–1854. doi:10.3201/eid1412.080876.
- Blanton J.D., Palmer D. & Rupprecht C.E. (2010). – Rabies surveillance in the United States during 2009. *JAVMA*, **237** (6), 646–657. doi:10.2460/javma.237.6.646.
- Rupprecht C.E., Barrett J., Briggs D., Cliquet F., Fooks A.R., Lumlertdacha B., Meslin F.-X., Müller T., Nel L.H., Schneider C., Tordo N. & Wandeler A.I. (2008). – Can rabies be eradicated? *Dev. Biol. (Basel)*, **131**, 95–121.
- Blanton J.D., Palmer D., Dyer J. & Rupprecht C.E. (2011). – Rabies surveillance in the United States during 2010. *JAVMA*, **239** (6), 773–783. doi:10.2460/javma.239.6.773.
- Nel L.H. & Markotter W. (2007). – Lyssaviruses. *Crit. Rev. Microbiol.*, **33** (4), 301–324. doi:10.1080/10408410701647602.
- Nel L.H. & Rupprecht C.E. (2007). – Emergence of lyssaviruses in the Old World: the case of Africa. In Wildlife and emerging zoonotic diseases: the biology, circumstances and consequences of cross-species transmission (J.E. Childs, J.S. Mackenzie & J.A. Richt, eds). Springer, Berlin, Heidelberg, Germany, 161–193. doi:10.1007/978-3-540-70962-6_8.
- Knobel D.L., Cleaveland S., Coleman P.G., Fèvre E.M., Meltzer M.I., Miranda M.E.G., Shaw A., Zinsstag J. & Meslin F.-X. (2005). – Re-evaluating the burden of rabies in Africa and Asia. *Bull. WHO*, **83** (5), 360–368. doi:10.1186/S0042-96862005000500012.

12. Hampson K., Coudeville L. [...] & Dushoff J., on behalf of the Global Alliance for Rabies Control Partners for Rabies Prevention (2015). – Estimating the global burden of endemic canine rabies. *PLoS Negl. Trop. Dis.*, **9** (4), e0003709. doi:10.1371/journal.pntd.0003709.
13. Fooks A.R., Banyard A.C., Horton D.L., Johnson N., McElhinney L.M. & Jackson A.C. (2014). – Current status of rabies and prospects for elimination. *Lancet*, **384** (9951), 1389–1399. doi:10.1016/S0140-6736(13)62707-5.
14. Pasteur M.L. (1885). – Méthode pour prévenir la rage après morsure. *Comptes rendus des Séances de l'Académie des Sci.*, **17**, 765–772.
15. Nel L.H. (2013). – Factors impacting the control of rabies. *Microbiol. Spectr.*, **1** (2), 1–12. doi:10.1128/microbiolspec.OH-0006-2012.
16. Lembo T., Atatlan M. [...] & Briggs D.J. (2011). – Renewed global partnerships and redesigned roadmaps for rabies prevention and control. *Vet. Med. Int.*, **2011**, 923149. doi:10.4061/2011/923149.
17. World Health Organization (WHO) (2005). – WHO Expert Consultation on Rabies: first report. WHO, Geneva, Switzerland. Available at: www.who.int/iris/handle/10665/43262 (accessed on 18 April 2018).
18. Zeng H., Pappas C., Katz J.M. & Tumpey T.M. (2011). – The 2009 pandemic H1N1 and triple-reassortant swine H1N1 influenza viruses replicate efficiently but elicit an attenuated inflammatory response in polarized human bronchial epithelial cells. *J. Virol.*, **85** (2), 686–696. doi:10.1128/JVI.01568-10.
19. Taylor L.H. & Knopf L. (2015). – Surveillance of human rabies by national authorities – a global survey. *Zoonoses Public Health*, **62** (7), 543–552. doi:10.1111/zph.12183.
20. Nel L.H., Scott T.P., Wright N., Mollentze N., Markotter W., Sabeta C.T. & le Roux K. (2011). – Rabies and rabies control in African regions. In *Rabies control – towards sustainable prevention at the source: compendium of the OIE Global Conference on Rabies Control, 7–9 September 2011, Incheon, Seoul (Republic of Korea)*. World Organisation for Animal Health (OIE), Paris, France, 51–58. Available at: www.oie.int/doc/ged/D12061.PDF (accessed on 18 April 2018).
21. Nel L.H. (2013). – Discrepancies in data reporting for rabies, Africa. *Emerg. Infect. Dis.*, **19** (4), 529–533. doi:10.3201/eid1904.120185.
22. World Health Organization (WHO) (2017). – Neglected tropical diseases: WHO, FAO and OIE unite in their goal to eliminate human rabies and control the disease in animals. Available at: www.who.int/neglected_diseases/WRD_rabies_2013/en/ (accessed on 15 August 2017).
23. Balam D., Taylor L.H., Doyle K.A.S., Davidson E. & Nel L.H. (2016). – World Rabies Day – a decade of raising awareness. *Trop. Dis. Travel Med. Vaccines*, **2** (1), 19. doi:10.1186/s40794-016-0035-8.
24. Kakkar M., Venkataramanan V., Krishnan S., Chauhan R.S. & Abbas S.S. on behalf of the Roadmap to Combat Zoonoses in India (RCZI) initiative (2012). – Moving from rabies research to rabies control: lessons from India. *PLoS Negl. Trop. Dis.*, **6** (8), e1748. doi:10.1371/journal.pntd.0001748.
25. Yin W., Dong J., Tu C., Edwards J., Guo F., Zhou H., Yu H. & Vong S. (2013). – Challenges and needs for China to eliminate rabies. *Infect. Dis. Poverty*, **2** (1), 23. doi:10.1186/2049-9957-2-23.
26. Schneider M.C., Belotto A., Adé M.P., Hendrickx S., Leanes L.F., Rodrigues M.J.D.F., Medina G. & Correa E. (2007). – Current status of human rabies transmitted by dogs in Latin America. *Cad. Saude Publica*, **23** (9), 2049–2063. doi:10.1590/S0102-311X2007000900013.
27. Belotto A., Leanes L.F., Schneider M.C., Tamayo H. & Correa E. (2005). – Overview of rabies in the Americas. *Virus Res.*, **111** (1), 5–12. doi:10.1016/j.virusres.2005.03.006.
28. Lembo T. (2012). – The blueprint for rabies prevention and control: a novel operational toolkit for rabies elimination. *PLoS Negl. Trop. Dis.*, **6** (2), e1388. doi:10.1371/journal.pntd.0001388.
29. Food and Agriculture Organization of the United Nations (FAO) & Global Alliance for Rabies Control (GARC) (2012). – Developing a stepwise approach for rabies prevention and control. Proc. of FAO/GARC Workshop, November, Rome, Italy. FAO, Rome, Italy. Available at: www.fao.org/docrep/019/i3467e/i3467e00.htm (accessed on 18 April 2018).
30. Coetzer A., Kidane A.H., Bekele M., Hundera A.D., Pieracci E.G., Shiferaw M.L., Wallace R. & Nel L.H. (2016). – The SARE tool for rabies control: current experience in Ethiopia. *Antiviral Res.*, **135**, 74–80. doi:10.1016/j.antiviral.2016.09.011.
31. Partners for Rabies Prevention (2014). – The stepwise approach towards rabies elimination: a tool for planning and evaluation. Available at: <http://caninerabiesblueprint.org/A-stepwise-approach-to-planning> (accessed on 13 August 2017).
32. Global Alliance for Rabies Control (GARC) (2017). – Global Alliance for Rabies Control. Available at: <https://rabiesalliance.org/> (accessed on 9 May 2018).
33. Wallace R.M., Undurraga E.A., Blanton J.D., Cleaton J. & Franka R. (2017). – Elimination of dog-mediated human rabies deaths by 2030: needs assessment and alternatives for progress based on dog vaccination. *Front. Vet. Sci.*, **4**, Article 9. doi:10.3389/fvets.2017.00009.

