

20 Conclusions

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The aim of this book was to bring together practical, real-world experiences with dog rabies control and dog-mediated human rabies elimination at the ground level, with the purpose of sharing ideas, suggestions and lessons learnt on how to accelerate towards dramatically reducing the burden of this lethal disease in animals and humans. It is unlikely that the goal of reaching zero human rabies deaths by 2030 will be achieved in all rabies-endemic countries, but crucial progress can be made in the next few years to set the groundwork for the 'last mile' in the decade 2030–2040. With this timeline in mind, we hope that this collection will be of inspiration for current but especially prospective rabies practitioners, decision makers, scholars and any stakeholders across any sector, discipline, community and country – within and outside Asia.

This concluding section builds on the take-home message that we, as editors, asked each chapter author to provide, as well as the messages that we personally took home from two international meetings that we attended in autumn 2022 when we were writing the conclusions of this book. These two events are the Rabies in the Americas conference (Mexico, October 2022) and the World One Health

Congress (Singapore, November 2022), where rabies was among the most represented diseases. These take-home messages can be recapitulated as follows.

The international rabies community requires collaboration from social scientists, communication specialists, and economics and policy experts in order to understand what obstacles are hampering a fast and smooth transition from the theory to the practice of rabies elimination. Particular attention must be paid to mass dog vaccination and the need to implement it wherever necessary in a coordinated, systematic and sustained way. The future of rabies elimination lies in persistence. While mass dog vaccination is widely advocated, it is the lack of sustained implementation that is causing this control method to fall short of its yearly target goals, as well as the 2030 goal.

To do this, the adoption of a collaborative, intersectoral One Health approach is integral to success. The Association of South-east Asian Nations (ASEAN) should aim to advance competencies in One Health science and implementation, by developing more capable leaders and advocates who fully embrace the One Health approach. ASEAN member states should strive to narrow the One Health development gaps,

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commit to establishing formal One Health multi-sectoral coordination mechanisms, and look for incentives to collaborate between stakeholders to break down siloed approaches. This is crucial not only to co-design and co-implement rabies control strategies, but also to strengthen the surveillance of human, dog and wildlife rabies. Moreover, because of the crucial importance of cross-border mass dog vaccination, regional networks such as ASEAN can play a key role in ensuring that not only single countries, but entire areas of the world, move fast towards rabies elimination.

Structured conversational processes such as the World Café are very helpful to create a safe, welcoming environment where it is possible to increase awareness on why and how to eliminate rabies, connect and share multiple ideas and perspectives, generate novel solutions, and encourage collective action. The assumption is that collective discussion can trigger the paradigm shift that a One Health approach to rabies control requires.

One Health collaboration needs to include rabies stakeholders at all levels of society, from the international to the local one. At the local level, the network should include not only communities and traditional stakeholders (within and outside the health sector) but non-traditional stakeholders as well, such as religious leaders and traditional healers. This is necessary because rabies control strategies need to be tailored to the local social, cultural and religious context, and to build on local networks, resources and communication channels.

Rabies One Health networks also need to consider animal welfare activists, to ensure, if possible, that all rabies stakeholders are working towards the same goal – although, sometimes, in different ways. For example, animal welfare activists can be pivotal in convincing government bodies and civil society that dog culling is not only ineffective, but counterproductive, in controlling dog rabies.

We need to make a strong investment case to finance mass dog vaccination as the most cost-effective control measure considering the high costs of post-exposure prophylaxis (PEP) and overall rabies control. Financial resources for mass dog vaccination should come from both the human and the animal health sectors. Examples of this One Health co-investment

model built on the principle of preventing rabies at the source (i.e. dogs) – and not just treating dog bites in humans – are available.

The mass vaccination of puppies, using rabies vaccines of high immunogenic capacity, can make it easier to achieve and maintain 70% vaccination coverage. Additionally, the introduction of oral dog vaccination can be a game changer in complementing parenteral vaccination, by enhancing vaccination coverage in hard-to-catch free-roaming dogs. Evidence exists to demonstrate the feasibility and scalability of oral dog vaccination and its potential contribution to the elimination of dog-mediated human rabies. Coordination and assistance among countries, development partners and the private sector are urgently needed to make the best use of this tool.

Dog ecology influences the efficacy of mass dog vaccination. The collection of field data is essential to improve knowledge of local aspects such as population size and roaming ranges, habitat utilization, pack sizes, contacts, and dog population demographics and dynamics, and to form the basis of evidence-based animal and public health policy for the control of dog rabies.

The contribution of dog population management to rabies control is in increasing the accessibility of free-roaming dogs, through measures such as the promotion of responsible behaviour, veterinary care, dog vaccination, dog population control, dog bites and rabies awareness, and law enforcement. The Asian continent has a high free-roaming dog population and relatively little investment in dog population management systems and associated small-animal veterinary services. Dog population management should provide an opportunity to bring additional funding, political will, and community support based on its wider aims reaching beyond only rabies control. Nevertheless, it should not divert resources away from vaccination. Rather it should support greater vaccination coverage and drive down the cost of vaccination campaigns and PEP.

Lacking or poor waste management increases the quantity of food available to free-roaming dogs and supports the growth of their population, which in turn decreases the fraction of vaccinated dogs. Efficient waste management is necessary to complement dog population

management and support mass dog vaccination efforts.

Accurate epidemiologic data both for humans and for animals is significant in streamlining rabies prevention and control and evaluating the success of intervention strategies. To have accurate data, laboratory confirmation is of utmost importance. The straw and hook methods are techniques for brain specimen collection that are reliable, cheap, fast and easy to perform, and require fewer biosafety requirements compared to opening the skull (the standard method of collecting brain specimens for rabies diagnosis).

Advancements in high throughput DNA sequencing tools and genomic techniques can help to better understand the transmission of rabies across geographies, the emergence of new lineages, and host-specific evolutionary and transmission dynamics of the virus. Whole-genome sequences can help classify circulating rabies strains for the identification of high-risk areas and targeted control programmes for rabies elimination in Asia. With further optimization of protocols, training of professionals, and infrastructure, these advanced techniques can facilitate rabies surveillance.

Resource-limited countries should implement cost-effective, PEP-saving measures, to benefit both national health systems and at-risk communities. Vaccine-pooling strategies that adopt the intradermal administration of vaccines are cost-effective options designed to administer fractional doses of rabies biologicals, without compromising efficacy and by making sure that PEP is always available and free of charge for high-risk populations.

Animal Bite Treatment Centres provide an efficient system for widespread PEP delivery at the local level, but this infrastructure needs to be complemented with an animal investigation for a more holistic approach to bite management and for making sure that expensive PEP is used only when necessary. Collaboration between animal and human health workers should be strengthened, for example through the setting up of an Integrated Bite Case Management system.

Based on Japan's experience in the pre-elimination stage of rabies, robust and cross-sectoral surveillance, mandatory pet dog registration, the maintenance of high levels of dog vaccination coverage, free-roaming dog population control, and continuous awareness-raising are indispensable tools to achieving and maintaining rabies elimination.

If an impact is to be made by 2030, it is crucial to implement and scale up mass dog vaccination and PEP delivery to target those people and dogs living in socially, economically and marginalized areas. Actual rabies prioritization (beyond formal disease prioritization workshops) and long-term political and financial commitment to a One Health approach to rabies elimination are now all that is necessary to reach the final goal as soon as possible. When advocating for rabies elimination, it is useful to remember that:

- We have the tools and the knowledge to start making an impact now, and improving interventions as we go.
- Rabies is 99.9% fatal but 100% preventable: let's make that 0.1% count.
- Rabies elimination contributes to the achievement of several Sustainable Development Goals: (1) no poverty, (3) good health and well-being, (10) reduced inequalities and (17) partnerships for the goals.
- Rabies elimination strengthens health systems to the benefit of neglected and non-neglected diseases.

There is no single, simple solution to eliminate dog rabies from endemic areas nor to achieve zero human rabies deaths. Every aspect of rabies control carries a set of challenges to overcome in order to be successful. A multi-pronged approach is hence needed, centring around a One Health collaborative effort. We must emphasize the need for sustained mass dog vaccination, continuous communication and open information sharing to learn from one another's successes.

Authors' Declaration

All authors declare that they have no conflict of interest.

All authors have approved this manuscript, agree with its submission, and share collective responsibility and accountability.

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