

Institution: University of Edinburgh/Scotland's Rural College		
Unit of Assessment: 6		
Title of case study: I: Implementation of large-scale vaccination programmes to control rabies in dogs and protect human health		
Period when the underpinning research was undertaken: 2003 – 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Sarah Cleaveland	Senior Lecturer in Veterinary Epidemiology	1998 – 2008
Richard Mellanby	Chair of Comparative Medicine	2007 – present
Mark Bronsvort	Chair of Veterinary Epidemiology	2007 – present
Ian Handel	Senior Lecturer	2005 – 2019 (retired)
Stella Mazeri	Postdoctoral Epidemiologist	2016 – present
Period when the claimed impact occurred: August 2013 – December 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact		
<p>Underpinning Research: Our research showed for the first time that vaccinating 70% of dogs can reduce both canine and human cases of rabies. We have subsequently shown that dog vaccination strategies can be scaled up effectively in different epidemiological settings, through a synergistic partnership with the charity Mission Rabies.</p> <p>Significance and Reach of Impact: Vaccination strategies informed by our research have led to regional reductions in human rabies cases in Blantyre (Malawi) and Goa (India). In Goa, human mortality from rabies fell from 17 cases in 2014 to sustained zero in 2018 and 2019, while canine rabies cases fell from 75 cases in 2014 to 8 in 2019.</p> <p>Successful canine vaccination programmes have been rolled out in 7 low-to-middle income countries (India, Sri Lanka, Uganda, Tanzania, Malawi, Ghana and Thailand) using a mobile health smartphone application that we designed together with Mission Rabies. By December 2020, these programmes had vaccinated a total of 1,490,000 dogs. The app is also used for routine rabies vaccination surveillance and control by the Center for Disease Control and Prevention and the charity Mayhew International in endemic and emergency settings.</p> <p>Our research has set the target of 70% canine vaccination for the United Against Rabies' "Zero by 2030" rabies-elimination campaign (2018). The research is repeatedly cited by international public health guidelines such as those of World Health Organization (WHO) as the basis of strategies to eliminate human deaths from rabies.</p>		
2. Underpinning research		
The Challenge: Rabies kills many people at high cost in low- and middle-income countries		
<p>Rabies is a zoonotic disease that kills approximately 59,000 people each year. It has one of the highest case fatalities of any infectious disease, with patients almost always succumbing to the infection once clinical signs develop. The global cost of rabies has been estimated at USD8,600,000,000 (GBP6,230,616,000; 02-21), with the loss of more than 3,700,000 disability-adjusted life years. The majority of cases occur in low- and middle-income countries in sub-Saharan Africa and south-east Asia, notably India.</p> <p>We have long-term expertise in developing strategies to reduce the incidence of rabies in both human and canine populations. Our work has addressed two fundamental questions to shape this area of public health:</p> <ol style="list-style-type: none"> 1) Can vaccinating dogs against rabies protect both dogs and humans? 2) Can this be scaled to regional disease elimination programmes in different epidemiological settings? 		

Mass dog vaccinations reduce human rabies incidence

Pioneering research conducted by Cleaveland in 2003 demonstrated that vaccinating nearly 70% of dogs in the Serengeti District of Tanzania resulted in a 97% decline in canine rabies cases after 2 vaccination campaigns. Over the same period, the incidence of dog rabies in unvaccinated control villages did not change significantly [3.1]. Cleaveland also showed that dogs are the main reservoir of rabies in sub-Saharan Africa and that the rabies virus was not maintained to any significant extent in wildlife populations [3.2]. These studies were critically important in demonstrating that vaccinating 60-70% of dogs was sufficient to control dog rabies and could lead to a significant reduction in demand for human post-exposure rabies treatment.

Scaling up mass dog vaccination in Malawi where paediatric rabies is high and dogs are mainly household-owned

Nevertheless, it remained challenging to scale up dog vaccination programmes beyond the pilot study and to develop a flexible toolbox of approaches that could be effective in regions where dog ecology was vastly different. Collaborating closely with the charity Mission Rabies, we addressed this challenge in Malawi, where rabies is particularly problematic and is estimated to cost the country USD13,000,000 (GBP9,416,500; 02-21) and cause 484 human deaths per year, mainly in children. We focussed on the Blantyre region, which reported one of the highest incidences of paediatric rabies in Africa in 2012, and demonstrated the feasibility of vaccinating more than 35,000 dogs over a short time period, in this case 20 days, achieving more than 70% vaccination coverage in dogs that were mainly household-owned [3.3].

We also developed a novel methodology, utilising continuous monitoring of the vaccination progress with a bespoke mHealth app, now known as the World Veterinary Services (WVS) app. This technology allowed us to understand why owners do not attend static point vaccination clinics, and thus provided the evidence base for the development and roll-out of a more cost-effective combination of fixed and roaming vaccination clinics [3.4]. This has resulted in further improvements in vaccination throughput, with a further 34,000 dogs vaccinated over 11 days with fewer personnel [3.4].

Scaling up mass dog vaccination in Goa where most dogs are unowned and free-roaming

Implementing mass vaccination programmes is particularly difficult in India where more than 20,000 people die from rabies each year. The majority of dogs in India are free-roaming, which makes it challenging to restrain them for vaccination. Together with Mission Rabies, we developed a novel vaccination strategy, targeted to these circumstances, that has allowed more than 70% of free-roaming dogs to be vaccinated in several Indian cities with the use of the WVS app [3.5; 3.6]. This mHealth app facilitated the rapid collection of details of each healthcare intervention, including patient information and precise geographical location. Critically, it enabled field workers to operate in tightly defined areas to ensure unified vaccination coverage and rapid, real-time detection of low-coverage regions, which facilitated further rounds of vaccinations [3.6].

Attribution and recognition: Research was initiated by Cleaveland and further developed by Mellanby, Bronsvort and Mazeri at this unit with substantial contribution of the PhD student Gibson and charity Mission Rabies, which was established in 2013 to eliminate rabies using an evidence-based OneHealth approach. The work was recognised in 2019 with a UoE Chancellor's Award for Impact to Mellanby *"for the impact of his work in developing strategies for rabies elimination in dogs in the developing world and the resulting dramatic decline in human rabies deaths"*.

3. References to the research

- [3.1] Cleaveland S, Kaare M, Tiringa P, Mlengeya T, Barrat J. A dog rabies vaccination campaign in rural Africa: impact on the incidence of dog rabies and human dog-bite injuries. *Vaccine* 2003;21:1965-73. doi: [10.1016/S0264-410X\(02\)00778-8](https://doi.org/10.1016/S0264-410X(02)00778-8)
- [3.2] Lembo T, Hampson K, Haydon DT, Craft M, Dobson A, Dushoff J, Ernest E, Hoare R, Kaare M, Mlengeya T, Mentzel C, Cleaveland S. Exploring reservoir dynamics: a case study of rabies in the Serengeti ecosystem. *J Appl Ecol* 2008;45:1246-57. doi: [10.1111/j.1365-2664.2008.01468.x](https://doi.org/10.1111/j.1365-2664.2008.01468.x).

[3.3] [Gibson AD](#), [Handel IG](#), Shervell K, [...] [Bronsvoot BM](#), [Mellanby RJ](#), Gamble L. The Vaccination of 35,000 Dogs in 20 Working Days Using Combined Static Point and Door-to-Door Methods in Blantyre, Malawi. *PLoS Negl Trop Dis*. 2016;10:e0004824. doi: [10.1371/journal.pntd.0004824](https://doi.org/10.1371/journal.pntd.0004824)

[3.4] [Mazeri S](#), [Gibson AD](#), Meunier N, [Bronsvoot BMD](#), [Handel IG](#), [Mellanby RJ](#), Gamble L. Barriers of attendance to dog rabies static point vaccination clinics in Blantyre, Malawi. *PLoS Negl Trop Dis* 2018;12:e0006159. doi: [10.1371/journal.pntd.0006159](https://doi.org/10.1371/journal.pntd.0006159)

[3.5] [Gibson AD](#), Ohal P, Shervell K, [Handel IG](#), [Bronsvoot BM](#), [Mellanby RJ](#), Gamble L. Vaccinate-assess-move method of mass canine rabies vaccination utilising mobile technology data collection in Ranchi, India. *BMC Infect Dis* 2015;15:589. doi: [10.1186/s12879-015-1320-2](https://doi.org/10.1186/s12879-015-1320-2)

[3.6] [Gibson AD](#), [Mazeri S](#), Lohr F, Mayer D, Burdon Bailey JL, Wallace RM, [Handel IG](#), Shervell K, [Bronsvoot BMD](#), [Mellanby RJ](#), Gamble L. One million dog vaccinations recorded on mHealth innovation used to direct teams in numerous rabies control campaigns. *PLoS One* 2018;13:e0200942. doi: [10.1371/journal.pone.0200942](https://doi.org/10.1371/journal.pone.0200942).

Selected grants:

[3.7] Cleaveland S Optimising the design of rabies vaccination strategies in developing countries. 2003. Wellcome Trust. GBP266,986

[3.8] Mellanby R Development of strategies to manage free roaming dog populations. 2016-2018 Dogs Trust. GBP119,572

[3.9] Mellanby R Investigation of the impact of neutering on the welfare and population dynamics of free roaming dog populations. 2019-present Dogs Trust GBP333 542

4. Details of the impact

Impact on health and welfare

Mass dog vaccination strategies in Malawi and Goa were guided by the research data provided by our team and Mission Rabies. In the Blantyre region in Malawi, our One Health programme was rolled out in 2015 and resulted in a drop in paediatric rabies cases from an average of 4 cases per year between 2012 and 2015, to an average of 1 case per year between 2015 and 2017 [5.1].

In Goa, the incidence of human rabies declined from 17 cases in 2014 prior to the dog vaccination campaign, to sustained zero human rabies cases for 2 years in 2018 and 2019 [5.2a; **Figure 1**], meeting WHO criteria of a rabies-free declaration. During the same period, rabies cases in dogs reduced from 75 cases in 2014 to 8 cases in 2019 [5.2c]. The Head of the rabies epidemiology unit at the Centres for Disease Control and Prevention (CDC) was quoted in 2019 calling the control effort in Goa “one of the most successful programs in lower/middle income countries that I have seen in a decade.” [5.3]. The Director of the Goan Department of Animal Husbandry and Veterinary Services stated: “The research conducted into these [rabies control] activities reportedly through the University of Edinburgh has supported the development of effective methods of mass dog vaccination which have significantly reduced the canine rabies incidence [...], therefore reducing the risk of rabies to the people of Goa state.” [5.4].

In 2018, we played a key role in delivering workshop in Step-wise Approach to Rabies Elimination (SARE)¹ in Goa, involving representatives of the Goan government, CDC and WHO. This resulted in the creation of the Goa Rabies Control Task Force to drive the development of standard operating procedures for the rabies elimination and surveillance programme. Based on evidence provided by our team and Mission Rabies (e.g. data included in **Figure 1**), Goa received a SARE score of 3.5 out of a possible 5 [5.5a]. This was considerably higher than the rest of India, which received a SARE score of 1.5 in August 2019 [5.5b], highlighting the dramatic progress already made in reducing rabies burden in Goa.

¹ The SARE is a multi-stage planning, monitoring and evaluation tool that provides practical, measurable steps for rabies control programmes, and presents these steps as a logical flow of activities, from Stage 0 to Stage 5.

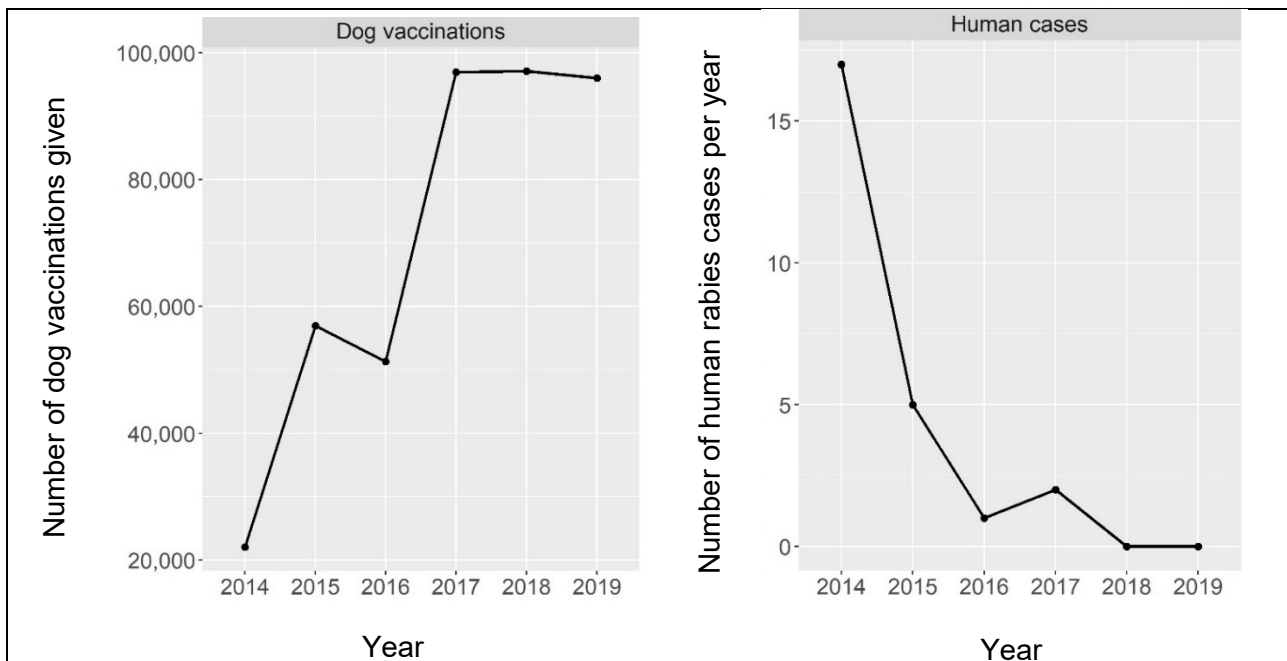


Figure 1. Graphs showing annual numbers of dog vaccinations increasing and human rabies cases declining as a result of the vaccination campaign in Goa between 2014 and 2019 [5.2d,a].

Impact on policy and guidelines

WHO guidelines from 2018 highlight the significance of dog vaccinations on rabies control, citing our vaccine coverage and rabies burden work, as well as our more recent applied research on vaccination strategies (e.g. [3.2]; Knobel *et al* 2005 Bull WHO²) [5.6a,b]. Significantly, our findings helped set the 70% canine vaccination target for the United Against Rabies “Zero by 2030” rabies elimination campaign [5.6b]. In 2018, we were invited to write an expert chapter on rabies in stray dogs based on our research for the Scientific and Technical Review for the World Organisation for Animal Health, reflecting our internationally recognised expertise in rabies vaccination programmes [5.6c].

Impact of mHealth app on rabies surveillance and vaccination practice in 7 countries

Rabies surveillance and mass vaccination strategies have significantly improved through the mHealth application developed jointly by our team and Mission Rabies [e.g. 3.5].

Mission Rabies has rolled out canine vaccination programmes in 7 low-and-middle income countries – India, Sri Lanka, Uganda, Tanzania, Malawi, Ghana and Thailand – using the WVS app to systematically guide vaccination teams in near real-time [3.6]. By December 2020, Mission Rabies had vaccinated 1,490,000 dogs [5.7].

The WVS app has also been adopted by other major international organisations, including the CDC and the charity Mayhew International, for efficient mass vaccination programmes. Through CDC-led activities, more than 200,000 dogs were vaccinated in Haiti in 2017 [5.8a], and Mayhew has overseen vaccination of 64,828 dogs in Kabul, Afghanistan between 2017 and 2019 [5.8b]. The CDC has further developed the app as an Integrated Bite Case management system that actively follows up cases and helps surveillance and implementation [5.9]. This has been used by the CDC to gather data for emergency outbreak responses, such as in Haiti and the Dominican Republic in January 2019.

This scaling up of Mission Rabies’s operational work and use of the WVS app is underpinned by our research expertise [5.7]. Its Director of Strategic Research stated: “*The contribution of the University of Edinburgh has been transformative in our ability as a charity to bring high quality research to the field of rabies control over the past five years. Through the analytical expertise*

² [doi: /S0042-9686\(20\)050005-0](https://doi.org/10.1016/S0042-9686(20)050005-0)

offered by the University of Edinburgh it has been possible to analyse big data in a way that would otherwise been out of our reach. This has resulted in a far greater depth of understanding into operational effectiveness of mass dog vaccination campaigns which has enabled us to continue to develop effective solutions to rabies control at scale.” [5.10a]. The Mission Rabies Chief Executive added “Mission Rabies could not have expanded the operational work as quickly and efficiently without the expertise provided by University of Edinburgh, which provided clarity of the interpretation of research data and invaluable input into future strategies.” [5.10b].

5. Sources to corroborate the impact

[5.1] Zimmer B, *et al.* Canine rabies vaccination reduces child rabies cases in Malawi. The Lancet 2018 392:1115-6 [doi: 10.1016/S0140-6736\(18\)32175-5](https://doi.org/10.1016/S0140-6736(18)32175-5)

[5.2] Evidence describing the drop in rabies cases in Goa:

- a. Letter from the National Rabies Control Programme, Goa, dated 19th Feb 2020, certifying number of human cases 2014-2019
- b. [The Indian Express](#). Zero deaths in 2018, Goa targets rabies-free 2020. 28th Jan 2019
- c. Number of dog cases in Goa from “Goa rabies elimination: Endgame proposal” submitted by Mission rabies to the Goan Government in November 2020
- d. Number of dog vaccinations in Goa from Mission Rabies annual report 2018 (p. 8)

[5.3] New York Times article “Rabies Kills Tens of Thousands Yearly. Vaccinating Dogs Could Stop It.” 22nd July 2019

[5.4] Testimonial letter from Director of Department of Animal Husbandry & Veterinary Services, Ministry of Health, Goa (15/06/2020)

[5.5] Step-wise Approach to Rabies Elimination (SARE) workshop in Goa, 26th April 2018

- a. Report from workshop
- b. Screenshot from website of [Global Alliance for Rabies Control, 27th Aug 2019](#). India: In-country SARE workshop defines needed steps towards rabies elimination

[5.6] International guidelines on rabies citing our research in chapters on prevention and control of rabies in dogs

- a. WHO 2018 WHO Expert Consultation on Rabies 3rd Report (citing 8 of our publications)
- b. United Against Rabies Zero by 30: The global strategic plan to end human deaths from dog-mediated rabies by 2030 (citing 2 of our publication out of 26)
- c. OIE Scientific and Technical Review: Gamble L, Gibson AD, Shervell K, Lohr F, Otter I, Mellanby RJ. Rev Sci Tech 2018; 37:543-50. [doi: 10.20506/rst.37.2.2822](https://doi.org/10.20506/rst.37.2.2822)
- d. OIE Do you know the World Organisation for Animal Health? leaflet

[5.7] Email from Mission Rabies re: total number of dogs vaccinated to 31st December 2020

[5.8] Adoption of WVS app by CDC and Mayhew International leading to dog vaccinations in Haiti and Afghanistan

- a. Cleaton J, *et al.* 2018 Vaccine;36:2321-25 [doi: 10.1016/j.vaccine.2018.03.017](https://doi.org/10.1016/j.vaccine.2018.03.017)
- b. Mayhew International website [page on Kabul](#)
- c. Mayhew International 2017 annual report, confirming collaboration with Mission Rabies

[5.9] Adrien J, *et al.* 2019 Morb Mortal Wkly Rep;68:707–709. [doi: 10.15585/mmwr.mm6832a6](https://doi.org/10.15585/mmwr.mm6832a6)

[5.10] Testimonial letters from Mission Rabies

- a. Director of Strategic Research, Mission Rabies (16th June 2020)
- b. Chief Executive, Mission Rabies (16th June 2020)