By 1999, general principles had also emerged for reconciling the maddening confusion of definitions. These principles helped to differentiate the control of an organism (with continued disease and control measures) from its elimination (absence of disease but requiring continued control measures), eradication (global elimination such that control measures could stop but that could require bio-containment of stocks), and extinction.[11]

A recent success

Very early in the 21st century, new knowledge was already informing these concepts as an alarming new disease went from discovery to worldwide elimination in a remarkable nine months through the international application of classic public health measures. Although the severe acute respiratory syndrome (SARS) may yet re-occur or re-emerge from a non-human reservoir,[12] its worldwide elimination showed that extraordinary political and societal support could sustain a massive, coordinated, public health effort long enough to interrupt transmission of an organism globally. Interestingly, the biological and technical feasibility of SARS elimination was at best speculative at the outset of that effort (no diagnostic test even existed when it first emerged).

Conclusions and outlook

As this brief account shows, the "science" of eradication is still very young, and much is still to be learnt. Eradication may, for example, be not only an appropriate goal in disease control for some ancient scourges but the preferable goal to control some new pathogens rapidly. This should not be lost in the debate that always surrounds eradication because the window of opportunity for eliminating a disease globally can be very narrow (smallpox eradication may not have been possible in the HIV era because of the risk of fatal adverse events following the immunisation of infected individuals). Beyond polio and guinea worm, the current list of potentially eradicable human pathogens is quite short. That list includes measles, however, a disease that killed as many children as HIV in 2000.[13] Measles, for which diagnosis is cheap and simple, has already been eliminated from large geographical areas by using a vaccine that costs just $0.17 per dose.[14]

Although the eradication of human and animal pathogens have many parallels, joint work has to date been limited to the sharing of experience and best practices in areas such as strategic approach, surveillance and certification, and advocacy and mobilisation of resources. With the UN Food and Agriculture Organisation's global rinderpest (cattle plague) eradication programme (GREP) now showing that eradication of an animal pathogen may indeed be feasible[15] and the emerging importance to both humans and animals of pathogens such as avian influenza, it is intriguing to consider the possibility of joint eradication programmes in the future. The likelihood and success of any future eradication initiative will, however, depend on first securing and then sustaining a level of international consensus and support that no eradication effort, whether against a human or animal pathogen, has yet to enjoy.

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The animal story

Peter L Roeder

The UN Food and Agriculture Organisation's global rinderpest eradication programme (GREP)—the first and only attempt to eradicate an animal pathogen—provides several learning points from the veterinary perspective

Emergency Prevention System for Transboundary Animal Diseases, Animal Health Service, Food and Agriculture Organization of the United Nations, Vialle delle Terme di Caracalla, 00100 Rome, Italy
Peter L Roeder
animal health officer
peter.roeder@fao.org

Rinderpest is (was is possibly more accurate) an ancient disease of cattle, believed to have been the origin of human measles,[1] caused by an epitheliotropic and lymphotropic morbillivirus. Characterised by high fever, ocular and nasal discharges, dysentery, and dehydration it can cause death in up to 100% of cattle, water buffaloes, and yaks. Many wild ungulates are also highly susceptible, but not humans. Not surprisingly, it was the dread of farmers throughout the European, Asian, and African continents for centuries, even millennia. Sweeping west, east, and south out of central Asia, this devastating disease changed the course of history, following in the wake of marauding armies bringing death and devastation that contributed to the fall of the Roman empire, the conquest of Europe by Charlemagne, the French revolution, the impoverishment of Russia, and the colonisation of Africa.[2] Having been defeated in Europe by 1928, it was the subject of intensive eradication effort in Africa and Asia for most of the last century, yet not until 1993 was a programme mounted by the Food and Agriculture Organisation of the United Nations to bring about global eradication. The eradication programme aimed to provide coordination of autonomous, regional campaigns rather than being a centrally managed campaign. Twelve years later, in 2005, we are conceivably very close to the goal, with growing confidence that almost the whole world is now free; suspicion persists only for some pastoralist communities of the Horn of Africa, even though the virus has not been detected for four years.[3]

Herd immunity

Control, elimination, or eradication of rinderpest were long considered to depend almost solely on mass, pulsed vaccination campaigns, assuming that herd immunity would rise sufficiently to extinguish transmission of the virus. If it had been possible to maintain a sufficient proportion of the population immune for a sufficient length of time (taking into account ephemeral maintenance of virus by wildlife over which we had no control) one could surely have expected rapid success. But what is a sufficient proportion? How could high herd immunity be achieved? How long must it be sustained? Only lately have we started to gain epidemiological insights into answering these questions.[4]

West Africa as an example?

Annual campaigns targeted the most susceptible domestic species to achieve a desired seroprevalence between 80% and 90%, until the disease disappeared. Initially no time limit was set, but latterly the duration was set at three years, essentially for pragmatic reasons. This approach worked for West Africa, making it an often cited example: twice it proved relatively easy to free that region (or virtually all of it) early in campaigns that ran from the 1960s to the 1970s and 1986 to 1998. However, a more careful appraisal finds that mass rinderpest vaccination alone might not have been responsible for the perceived success. We know from field experience that high vaccination coverage, and even immunity, can be achieved in vaccination campaigns where the efficacy of immunisation is monitored and remedial action (revaccination) taken if needed.[5] However, most vaccination programmes fell far short of achieving the magical 90%, or even 80%, immunity figure. In fact, the figure rarely even reached 65% per cent, yet convincing evidence shows that the virus was eliminated from West Africa in 1988 after three years of mass vaccination. Perhaps the answer lies in the discovery that peste des petits ruminants (PPR), prevalent in West Africa and much of Asia, infects cattle, subclinically inducing immunity against rinderpest in up to 50% of cattle.[6] PPR immunity in the population summated with that of the rinderpest vaccine to give high herd immunity to rinderpest, explaining how elimination of rinderpest occurred despite suboptimal vaccination coverage, not only in West Africa but also in India.[7] It is fortunate that PPR fortified immunity conferred by vaccination because field studies and mathematical modelling indicate that moderate herd immunity actually helps to sustain viral transmission networks.[4]

VEIN

A case of rinderpest, showing ocular discharge

Vaccination not necessary

Combined with the understanding that it was difficult to achieve an adequately high immune population by annual, pulsed vaccination across the whole population at risk, we started to appreciate that it was actually not necessary and was wasteful of resources. In Ethiopia in the early 1990s, we realised that the areas of the country where rinderpest outbreaks were most evident were in fact "indicators" of spread from persisting, endemic reservoirs in remote, extensive, pastoral communities marginalised from services and surveillance. Eliminating these residual reservoirs of infection became the core issue in eradication. Mass vaccination was therefore relegated to the start of campaigns to reduce the frequency of outbreaks and disclose sustained virus transmission networks. Targeted vaccination programmes were mounted from 1993, using innovative, community based delivery systems, and this cleared rinderpest from the 35 million Ethiopian cattle herd within three years, something that 30 years of institutionalised, mass vaccination programmes had failed to do. A similarly focused approach achieved success in the sedentary village populations of southern India at about the same time.[8] The last handful of Asian and African endemic foci (except for the Somali ecosystem) were cleared by 2000. The most important lesson we learnt, perhaps rather slowly, was that a sound epidemiological understanding must precede, and be applied to guiding and focusing, any disease control programme.

GREP was designed with a deadline for fully accredited rinderpest freedom of 2010, and this has proved to be a wise move to provide a timetable to guide activities and focus minds.

The foregoing are the most important issues but other factors favouring the success of the programme deserve mention. These include:

- Active, adaptively managed, global coordination.
- A robust, efficacious, safe, and affordable vaccine[9] with a thermostable formulation[10] to avoid cold chain restrictions.
- An independent vaccine quality assurance service and production guidelines.
- Robust, affordable diagnostic tests; the ability to discriminate between wild infection and vaccination would have greatly facilitated surveillance as would penside tests if they had been available earlier.

- An international accreditation mechanism operated by the Office International des Epizooties.
- Guidelines for surveillance combined with performance indicators—the World Health Organization's pioneering work was taken as a model.[11 12]
- Molecular characterisation of viruses had a seminal effect on both epidemiological understanding and the conduct of eradication programmes. Designation of a world reference laboratory, hosted by the UK Institute for Animal Health, was invaluable.

Conclusions

Much has been learnt since the start of GREP that merits consideration when mounting control or eradication efforts for human or animal diseases. Whether other diseases will follow for eradication or be singled out for progressive control in geographically defined areas, as are foot and mouth disease and classical swine fever in Latin America, depends largely on the outcome of the global rinderpest eradication programme and the attitude of the international community towards funding such endeavours. There is no shortage of candidates, and new ones constantly arise. Medical and veterinary epidemic disease control is becoming a single continuum. The recent zoonotic Rift Valley fever, severe acute respiratory syndrome (SARS), Hendra virus or Nipah virus, and avian influenza indicate that we need to move on from separate human and veterinary scenarios.

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Synergy between public health and veterinary services to deliver human and animal health interventions in rural low income settings

Esther Schelling, Kaspar Wyss, Mahamat Bechir, Daugla Doumagoum Moto, Jakob Zinsstag

Rural African communities, especially those that are nomadic, often have poor access to health care. Collaboration with other services could help improve coverage

Department of Public Health and Epidemiology, Swiss Tropical Institute, PO Box CH-4002, Basle, Switzerland
Esther Schelling *research fellow*
Jakob Zinsstag *associate professor*
Swiss Centre for International Health, Swiss Tropical Institute
Kaspar Wyss *public health specialist*

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Livestock contribute to the livelihood of at least 70% of the worlds' rural poor.[1] In arid and semi-arid ecosystems of sub-Saharan Africa, livestock holders (mobile or settled pastoralists and agro-pastoralists) use vast grazing lands and residuals of crops that otherwise could not be used productively.[2] Yet, they are marginalised from development processes and vulnerable to exclusion from health services because of their geographical, social, and cultural environment. The weak infrastructure and quality of service in both the public health and veterinary sectors are closely related to resource constraints, especially lack of qualified staff.[3 4] Therefore, professionals from the World Health Organisation and UN Food and Agriculture Organisation have suggested that public health and veterinary services should share resources.[5 6] Few experiences of joint delivery of services to pastoral communities have been documented.[7] We describe the implementation and effects of a joint project in Chad.

Delivering essential interventions

Veterinary services have a crucial role in controlling highly contagious diseases and zoonotic infections, which have implications for human health as well as that of livestock. However, in many contexts veterinary services could also contribute to the provision of essential public health interventions. This is particularly important in areas with unacceptably low health service coverage, as is often the case in rural settings of low income countries. One example of collaboration between public health and veterinary services is in providing child vaccination, one of the most cost effective health interventions, in developing countries.[8] In southern Sudan, the Expanded Programme on Immunization shared cold chain equipment with the veterinary service,[7] and the International Red Cross has implemented vaccination campaigns using veterinarians' vehicles (B Peterhans, personal