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Veterinary Microbiology 44 (1995) 359–367

veterinary microbiology

The principles and practice of rinderpest eradication

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Accepted 4 January 1995

Abstract

Rinderpest can be controlled by interrupting its transmission. This objective can be achieved by implementing zoosanitary controls to eliminate or reduce the excretion of virus or by the use of vaccine to prevent the infection of fresh hosts. For success in the eradication of rinderpest these two techniques must be combined and used within time-bound campaign frameworks. The tools required for implementing rinderpest eradication are legal powers to declare farms to be infected premises and their surroundings to be infected areas, along with a cheap and efficacious vaccine. Finally, before embarking on rinderpest eradication an epidemiologically valid strategy must be adopted, financed and placed under competent management.

Keywords: Rinderpest; Eradication; Control of infection

1. Theoretical aspects of rinderpest control

1.1. Limiting the distribution of virus

Rinderpest virus is vulnerable to destruction by environmental influences and transmits only by close contact between excreter and recipient. It is therefore possible to interrupt its transmission by imposing zoosanitary control measures aimed at limiting the amount of virus excreted by infected animals or by physically preventing the excreted virus from reaching fresh hosts.

In the veterinary field, the most extreme method of limiting excretion is the slaughter and disposal of infected animals by rapid incineration or burial. For rinderpest, such measures are necessary wherever there is a danger that transmission may overrun existing defense mechanisms or where no defense mechanisms have been created. At a lesser extreme

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SSDI 0378-1135(95)00029-1

rinderpest infected animals may be allowed to endure the course of the disease but under conditions where their ability to transmit infection to other individuals is greatly reduced. Such sequestering measures include confinement inside stables or other farm buildings, or placing the infected individuals in special quarantine areas remote from other susceptible livestock. In either case supplementary steps must be taken to create a broad safety net around the focus of infection. Such steps are designed to limit the chance of rinderpest escaping from the vicinity of the outbreak and include limiting the activities of the owners of sick animals and the movement of all animals in the vicinity of the outbreak, the closure of neighbouring livestock markets and the disinfection of buildings and vehicles that might have become contaminated.

Zoosanitary controls represent cheap, rapid and effective ways of stamping out rinderpest. Their efficacy relates directly to the elimination of outbreaks as was shown when veterinary authorities used movement restrictions and compulsory slaughter to eradicate rinderpest from Europe before the turn of the last century. Yet in critical situations, if livestock owners evade these controls, disasters such as the Nigerian rinderpest pandemic of 1983 can be precipitated (Nawathe and Lamorde, 1984).

In spite of their obvious advantages, most infected countries still generally ignore opportunities to employ zoosanitary controls against rinderpest. However, as these controls now form an integral part of contemporary rinderpest eradication campaigns, we should perhaps attempt to understand why they have been so largely overlooked. In Africa, where large cattle herds are not uncommon, movement restrictions are probably ignored because of an overwhelming concern on the part of the owner or keeper as to the financial consequences of having his animals detained; his prime concern may be that his stock will deteriorate in value if they cannot move to find feed and water or if they cannot reach market by a certain time. Therefore, to gain the support of livestock owners in promoting the use of slaughter and quarantine measures, it may be necessary to provide them with free and comprehensive support during the period that they are detained, and to compensate them financially if either direct or indirect losses are sustained during this time.

In South Asia, where individual stock holdings are usually small, the failure to invoke zoosanitary controls in the fight against rinderpest is probably much more a question of an unwillingness by the community at large to accept the consequences of this approach. While individual farmers might accept monetary compensation for the destruction of diseased animals, public sentiment frequently opposes such decisions. However the livestock marketing industry's adverse reactions to movement restrictions and the closure of livestock fairs is probably a more important consideration. It is doubtful if zoosanitary principles can be fully implemented unless they can be linked with a compensation policy that embraces trade-associated losses.

1.2. Limiting the role of the recipient

Adopting a vaccination policy against rinderpest requires considerable capital investment in manufacturing capacity and cold chain distribution networks, as well as the recurrent annual costs of vaccination campaigns. Generally this policy is initiated in the face of endemic disease situations in countries where the widespread introduction of zoosanitary controls is only remotely possible. Ideally, a vaccination policy should bring a quick

investment return through a rapid reduction in the incidence of outbreaks, leading to the possibility of eradication by limited zoosanitary means. Although it has been demonstrated repeatedly that vaccination can reduce the number of outbreaks in a country it is also the case that unless neighbouring countries agree to proceed with eradication the danger of reinfection compels the continuation of vaccination.

Thus vaccination policies are frequently adopted as an interim measure and are maintained in the face of overwhelming evidence that, unless they make the transition to eradication policies, they will degenerate into an institutional activity. It is all too easy to see countries where this has happened. Unfortunately the efficiency of such repetitious work may suffer and institutionalised rinderpest vaccine campaigns can often give rise to semi-immune populations which actually conserve the virus they are supposed to eliminate.

In addition a financial treadmill is created. Where intensive vaccination nearly, but not quite, eliminates rinderpest the farmer is happy because he does not see much disease and he will not agitate for further controls as these may cause him some inconvenience. Veterinary Departments however, are left attempting to sustain this favourable situation without knowing how to eradicate the disease with the available budget and strategy yet not daring to relax their control measures as massive losses will again be experienced. In fact, it is the veterinary authorities rather than the farmer who now bear the economic burden caused by the continued presence of rinderpest – and the low level to which disease incidence has fallen is frequently these authorities' gift to the farmer. In other instances, where no rinderpest outbreaks have been seen for a substantial number of years in a particular region it is necessary for the member countries to recognise that rinderpest has in fact died out and that they should verify this fact rather than engage in further vaccination campaigns.

2. Practical aspects of rinderpest eradication

2.1. Introduction

Worldwide, rinderpest is a virus disease destined for extinction. (Anon, 1993). For this objective to succeed in the late 20th century a campaign orientation is needed and within each campaign five interlocking components have to be securely in place at the outset. These are:

- appropriate tools
- a relevant strategy
- international cooperation
- sufficient finance
- programme management

2.2. Tools

Introduction

Both zoosanitary controls and vaccination campaigns have a role to play in the eradication of rinderpest, but ultimate success will come from using these as complementary mechanisms. Up to now planning for rinderpest eradication has concentrated on the development

and the use of rinderpest vaccines and the chance to test the effectiveness of zoosanitary control measures has largely been lost. Nevertheless, in view of the probability of substantial savings in costs in comparison with vaccination work and the need to stamp out small foci of infection without recourse to vaccination, every opportunity should be given to put zoosanitary controls to work.

Zoosanitary controls

Because the imposition of zoosanitary controls is unpopular their use requires a high degree of political commitment and a sound framework of supporting legislation. Clearly this framework must provide veterinary authorities, probably acting with authority derived from their Minister, with powers requiring livestock owners to notify the presence of animals that could be suffering from rinderpest, and with powers to enter farms and farm buildings and examine animals thought to be suffering from the disease and to collect samples from suspected cases. At the same time the authorities must be able to declare a farm an infected premises, to prohibit the movement of animals from that farm and to compel the owner and his staff to avoid contact with animals on other farms. They should also have powers to declare the surrounding area to be a restricted area within which the movement of livestock is prohibited except by special licence and within which no public marketing of livestock is permitted. Powers should be available to order the safe destruction of infected animals or their detention within the infected premises until fully recovered; decisions as to which of these alternatives should to be applied should be related to the safety of the local farming community or exceptionally, to the safety of the national herd. Finally, and before lifting the restrictions, the compulsory disinfection of vehicles and premises should be covered by similar legislative orders.

Powers to declare an infected premises and prevent the removal of the sick animals should be constantly available to be invoked locally on the basis of a clinical diagnosis of rinderpest. Powers to declare infected areas and restrict the movement of livestock not within the infected premises should be restricted to national or sub-national (state) directors of veterinary services and then only on the presentation of laboratory evidence confirming the presence of the disease. Such restrictions probably require renewal every one to two weeks and should be rescinded immediately the outbreak ended.

Vaccine

Rinderpest vaccine confers life-long immunity (Plowright, 1984) and is safe, efficacious, cheap, easy to produce and easy to licence. For the past 25–30 years most countries where rinderpest still occurs have employed a tissue culture vaccine made with an attenuated derivative of the Kabete O strain (Plowright and Ferris, 1962). For use in the field vaccine must be distributed to a large number of different centres, sometimes over long distances; journey times will vary and the recipient may not always be ready to commence vaccination immediately the supplies arrive. Consequently, as the potency of fresh liquid vaccine degrades by 50% in around 10 days at 4°C, it has been necessary to increase its shelf-life to facilitate distribution and storage without loss of potency. Obviously the most practical approach to this problem was to freeze dry the product. Plowright et al. (1970), showed that freeze dried vaccine did not lose titre during four years at 4°C, while Mariner et al. (1990) constructed an Arrhenius plot to show that the shelf-life at this temperature can be

99 years. Clearly this product can be safely distributed and stored in any country that has an elementary cold chain.

In the early years of manufacture, tissue culture rinderpest vaccine was freeze dried in all-glass ampoules to a residual moisture level which was probably around 3% and which gave the product a degradation rate of approximately 0.0139 $\log_{10}$ per day at 37°C. or a half-life of 21 days (Plowright et al., 1970). More recently Mariner et al. (1990), have shown that the stability of the original vaccine can be increased by a lyophilisation routine that results in residual moisture levels of around 1 per cent. The potency of this vaccine degrades more slowly and, when combined with high product release titres, it has been able to satisfy minimum field potency standards after 30 days at 37°C. This slow-degrading rinderpest vaccine is now in use in some areas of Africa where cold chain facilities are lacking. However, as we have a vaccine which is almost indestructible under low temperature conservation, probably at several levels of residual moisture, and which can be manipulated to survive for a number of weeks at quite high ambient temperatures by increasing its release titre, many manufacturers will probably be satisfied with residual moisture levels of around 3%. What is perhaps more pertinent is the growing appreciation by rinderpest vaccine producer that poor field performance can be related to the poor sealing quality of the vials and stoppers in current use. Although this is an area in which improved tender specifications can induce changes in the manufacturing sector, for the time being campaign managers may wish to consider reverting to the use of all-glass ampoules for the creation of vaccine banks.

The stability of rinderpest vaccine is less after reconstitution than before freeze drying (cf 4°C half lives of 9–11 days before drying and 18 hours after drying and reconstitution) and the period immediately prior to inoculation is therefore the one when the vaccine is most vulnerable to thermal inactivation. But even here the decay parameters are known and, by developing a safety margin between the release titre and the field dose to be inoculated, a set of practical rules can be devised to ensure that the correct amount of vaccine is given. Clearly, if we can obtain good release titres, and if we know the potency required for a field dose, such a situation can be handled. In fact it is not difficult to obtain release titres of $10^{5.0}$ $TCID_{50}$/ml and as, by international agreement, the field-dose is $10^{2.5}$ $TCID_{50}$ it follows that the contents of a reconstituted 100 dose vial may decay from $10^{5.0}$ to $10^{4.5}$ $TCID_{50}$ and still contain the mandatory amount of virus. With post-rehydration degradation constants of 0.016 and 0.043 at 4 and 37°C respectively, reconstituted vaccine can be held at 4° for 31 hours or at 37° for 11 hours and at the end of these periods the vaccine will still conform to international norms with respect to field-dose levels. So, while we should not recommend keeping reconstituted vaccine from one day to the next it is difficult to see why reconstituted vaccine could not be used for longer than two hour period generally demanded.

2.3. Strategies for eradication

It is important that contemporary rinderpest eradication campaigns draw on the experiences of previous ones. If then we examine the singular achievements of the OAU/STRC Joint Campaign 15 (JP15) against rinderpest (Lepissier and Telli, 1971) we can see how the aggressive use of vaccine all but eradicated the virus from West Africa during the period 1961 to 1969 and that, had there been a way for individual countries to gain international

recognition of their subsequent rinderpest-free status, perhaps much of the post-JP-15 decay in rinderpest control in Africa might have been avoided. Unfortunately JP 15 lacked an agreement that defined the final conditions by which eradication could be verified once outbreaks had ended.

In an attempt to rectify this situation the Office International des Epizooties (OIE) defined three technical accomplishments whose successive demonstration allow a previously infected country to make a valid international declaration of freedom from rinderpest (Anon, 1990). Because successful attainment of the first objective prompts a series of actions leading to the second and third objectives, they have been termed "The OIE Pathway".

Entry to the pathway requires a contemporary commitment to eradicate rinderpest and takes place when a country has enjoyed 24 outbreak-free months and has apparently attained freedom from the disease, a point which the pathway sets out to validate. As achieving 24 outbreak-free months may well have involved the use of vaccine, and as there is always a possibility that vaccination masks the presence of infection, verification of this achievement is only possible once the use of vaccine has stopped. Therefore, should a country wish to progress along the pathway it must initiate the process by declaring itself provisionally free from rinderpest and simultaneously abandon the use of rinderpest vaccine in its bovine population. If, in the absence of vaccination, the country can demonstrate a further three years of freedom from outbreaks while making simultaneous attempts to unearth hidden foci, it may move to a substantive declaration of freedom from rinderpest disease. Finally, the country must undertake 24 months of effective rinderpest serosurveillance without discovering evidence of silent virus transmission before making a substantive declaration of freedom from rinderpest infection.

The pathway permits the first two declarations, but not the third, to be made for zones within a country which have experienced five years freedom from outbreaks. It is also understood that these declarations have to be supplemented by demonstrating the existence of effective veterinary services within the zones or countries in question and that these services investigate and resolve all outbreaks suggestive of rinderpest. These considerations lead only to the conclusion that countries embarking on rinderpest eradication in a contemporary framework must do so by examining the OIE pathway, determining where they are placed with respect to entering the pathway, whether the zonal concept has relevance in their context and what role vaccination and zoosanitary controls will play in their overall strategy.

2.4. International cooperation

National eradication campaigns can commence at any time and can be completely successful in their own right. However, if the virus persists in neighbouring countries there will be a constant danger of reinfection and the destruction of all that has been achieved. Although sanitary cordons can be considered as a means of ensuring that reinfection does not take place, their maintenance would represent an unwelcome expense to a country that has achieved freedom and would be unwelcome internationally in a climate where global eradication is the proposed goal. It follows then that in those regions where residual pockets of infection still occur, i.e. East Africa, South Asia and West Asia, it is imperative to proceed

within a regional context only, with each infected country involved in rinderpest eradication at a more or less the same time.

As has been demonstrated in India, a stagnant national control programme can be galvanised into an active and successful eradication programme by giving it a time frame within which to succeed. This time-bound approach is extremely useful both at a national level and, in the context of the OIE pathway, at an international level. It is therefore of considerable importance to develop this approach within regional programmes to ensure that where groups of infected countries exist side by side, their programmes are reasonably coordinated through regular joint review meetings.

2.5. *Financing eradication*

Countries that are still affected by rinderpest invariably subscribe to on-going national control programmes. Relative to the cost of disease losses, the cost of such vaccination campaigns are extremely high. Based on India's rinderpest programme budget for 1993–94, the cost to the nation of retaining control over rinderpest was 12 million ECU to the 25 State Governments and 2 million ECU to the Central Government. In the state of Tamil Nadu alone rinderpest control cost the State Government 1.13 million ECU and the Central Government 0.16 million ECU; at the same time the losses in Tamil Nadu due to outright mortality and loss of condition in recovered animals could be set at 68,927 ECU. In other words, according to these simplistic estimates it costs Tamil Nadu 19 times more to control rinderpest than is warranted in terms of direct disease losses. These chronic opportunity losses will recur every year until rinderpest is eradicated.

The conclusion to be drawn is that, even if relatively expensive for a short period, eradication is the only viable solution that can be advocated. It follows that national eradication programmes must be developed using the mechanisms, both physical and financial, available under these existing control programmes and that to a significant extent the finance for launching these programmes should already be in place. However, before realigning an existing control programme as an eradication programme it is important to examine the financial implications of this transition. In so doing it is essential to realise that eradication programmes must be totally committed to obtaining a rapid and absolute result and that there will be an escalation of short-term expenditures, with the expectation of massive savings in the years to come. It is up to participating countries to determine whether, in moving towards eradication, they need to make fresh investments to improve their vaccine manufacture, cold chain, vehicles, vaccination equipment, serosurveillance and disease reporting. If external financial assistance is needed, by way of loans or grants, solving this issue must be part of the project planning activity. It should be central to these financial considerations that rinderpest eradication be regarded as a public good and that appropriate public funding be made available.

2.6. *Programme management*

At both national and international levels, rinderpest programme management is important and specific managers or management units must be identified and mandated.

At a national level programme managers must have a clear understanding of the national agency or agencies implementing the programme and from where these agencies receive their finance. The managers should be aware of the international context within which the national programme is to be measured and should be given responsibility for the development of appropriate annual strategies either for the country as a whole or in zones within the country. They should also have responsibility for programming financial inputs to the executing agencies from all external sources (central to state government transfers, donor to state government transfers). They should also develop work plans that link the executing agents in the fulfilment of an annual national strategy and should be able to monitor executive progress during the course of the year. They should also have responsibility for funding, initiating and supervising any research contracts necessary for furthering their national programmes.

National programmes should function within a regional context and regional programme managers should attempt to cross-coordinate strategies in neighbouring countries. However, as rinderpest eradication campaigns are a temporary rather than permanent phenomenon, regional programmes should not promote the development of unsustainable regional institutions that assume duties more rightly belonging to national institutions. Should regional managers find the performance of national institutions to be unsatisfactory they should advocate strengthening rather than superseding them. Nor should they promote regional reference services where satisfactory linkages have already been established between national institutions and world reference centres. On the other hand regional programmes should promote the formation of research networks where one or more national research programmes are dealing with the same problem.

International organisations such as FAO and OIE have an important but indirect management role to play, through their powers to review the eradication processes within participating countries and to act as the ultimate arbiters of success. Although not a direct participant in either national or regional project management, OIE, through the OIE pathway, already influences strategy decisions in a number of countries and programme managers act in the knowledge that this is the only route by which their national declarations will receive full international attention. This rinderpest-related interface between OIE, FAO, National Authorities and Regional Authorities is perhaps the major area in which further attention is still required, particularly with regard to the need for external verification of national eradication claims. One solution to the overall concept of monitoring eradication efforts would be the creation of either an FAO or an OIE Rinderpest Commission with powers to comment on the progress towards global eradication to all interested parties.

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