STRATEGIES FOR VACCINATION OF FAMILY POULTRY AGAINST NEWCASTLE DISEASE IN AFRICA

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Abstract

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Criteria for the selection of vaccines against Newcastle disease (ND) appropriate for use in village chickens are discussed. Emphasis is given to the need to ensure that the selected vaccine is used successfully in the field. Those implementing ND control activities are encouraged to collaborate with all stakeholders and to develop comprehensive training and extension programs for field workers and farmers. Issues of cost-recovery and cost-minimisation are also discussed.

1. INTRODUCTION

The major constraint to production of village chickens in many developing countries is Newcastle disease (ND) [1, 2]. In these countries circulating strains of ND virus are capable of causing 100% mortality in unprotected flocks. Outbreaks of ND are unpredictable and discourage villagers from paying proper attention to the husbandry and welfare of their chickens.

In many cases, the vaccination of chickens against ND will be the first intervention implemented by veterinary services for village chicken farmers. Consequently, adequate time must be taken to ensure that, as well as employing an appropriate vaccine, due attention is given to training of field workers and farmers, the development of an appropriate extension package, and the establishment of a robust cost-recovery system.

2. COORDINATION OF ACTIVITIES

Newcastle disease control activities will have a better chance of being sustainable if all stakeholders are involved in the process from the outset. Possible stakeholders include farmers, extension workers, veterinary services staff, the private sector, livestock and social scientists and non-governmental organisations.

To gain long term support for ND control activities, it will be advantageous to raise awareness among senior decision makers of the contribution that can be made by family poultry to household food security, poverty alleviation and sustainable livelihoods. The level of long term support will determine the degree to which ND control activities can rely on government assistance and subsidies.

3. VACCINE SELECTION

Bell [3] briefly reviewed the advantages and limitations of the different vaccines available for use against Newcastle disease in village chickens (Table I). Inactivated vaccines give very good immunity without vaccinal reactions and have been widely used, but are relatively expensive and require considerable attention to training when used by non-veterinary personnel. Live vaccines are easy to apply and relatively inexpensive, and give moderately good immunity. Vaccinal reactions to them vary according to the vaccine strain. Among the live vaccines, the heat resistant vaccines require less stringent transport requirements in the field, and they have also been widely used in villages. Recombinant vaccines have the advantage that they can be serologically detected independently of the wild virus [3].

In South Africa a partially thermostable ND vaccine has become available through Intervet Pty. Ltd. The vaccine strain is ND Clone LZ.58, marketed by Nobilis as ND Inkukhu. It is a freeze-dried vaccine that in the freeze-dried form is stable for up to 7 days in temperatures not exceeding 30°C. At such temperatures the titre remains stable for seven days. Once reconstituted with a dilutent it should be treated as any standard freeze-dried ND vaccine. Furthermore, once removed from refrigeration for an extended period it must be used within the seven-day period and not returned to refrigeration for further storage.

The selection of a ND vaccine for use in family poultry will depend on the local conditions in each country. Selection criteria will include:

- Ease of use
- Thermostability
- Cost
- Immunogenicity
- Transportability
- Availability

In circumstances where the cold chain is weak or absent, the only reliable option will be the use of thermostable ND vaccines; i.e. the live vaccines NDV4-HR [4] and I-2 [5], or inactivated vaccines such as ITA-NEW and Newcavac. In most cases where farmers are to contribute wholly or partially to the cost of the vaccine, the price of the vaccine will be a major factor. The lower the price of the vaccine, the greater the number of farmers who will be able to afford to pay for it and, consequently, the greater the vaccination coverage. The lowest cost thermostable ND vaccine is generally locally produced I-2 "wet" vaccine. Locally produced freeze-dried I-2 ND vaccine is usually cheaper than imported freeze-dried live and inactivated thermostable vaccines, but it is more expensive than the "wet" vaccine. The freeze-drying process, the special vials, caps and labels all increase the price of the vaccine. However, freeze-dried vaccine does have a longer shelf life than "wet" vaccine.

It is advisable to conduct a risk analysis of the options available as the basis for the selection process. The risk analysis will also form part of the vaccine registration process. This analysis should be done in sufficient detail for all stakeholders to understand the risks and benefits associated with each option. The analysis will require more time and investigation in countries that opt to produce the ND vaccine locally. In countries where ND is endemic, the high mortalities associated with ND outbreaks will most likely indicate that the risks of not controlling the disease are far greater than the possible risks associated with a ND vaccine that is locally produced. The lower price of the locally produced vaccine (particularly the "wet" I-2 vaccine) will increase the number of birds that can be vaccinated with the funds available. In addition, locally produced vaccine requires much less foreign exchange.

TABLE I. A SUMMARY OF THE ADVANTAGES AND LIMITATIONS OF THE DIFFERENT VACCINE TYPES [3]

	Vaccine type					
	Inactivated	Live				Recombinant
		Lentogenic			Mesogenic	Velogenic
		Conventional	Cloned			
			Conventional	Heat Resistant		
Example	Newcavac	La Sota	Clone 30	I-2	Komarov	HVT/F
Immunogenicity	Very Good	Moderate	Moderate	Moderate	Good	Moderate
Vaccinal reaction	None	Moderate	Slight	Very slight	Severe	None
Ease of application	Difficult	Easy	Easy	Easy	Easy	Easy
Transportability	Good	Poor	Poor	Very Good	Poor	Moderate
Previous village use	Extensive	Some	No	Extensive	Yes	No
Spreadability	No	Yes	Yes	Yes	Yes	Yes
Seromonitorability	No	No	No	No	No	Yes
Cost	Moderate	Low	Low	Low	Low	High

4. THERMOSTABLE LIVE NEWCASTLE DISEASE VACCINES

A thermostable vaccine enables distributors and users to reduce the problems associated with inadequate cold chains in the field. It is essential that users understand that a thermostable vaccine must still be treated with some of the respect due to a biological product, that is, you cannot expose the vaccine to sunlight and frequent shifts in temperature and still expect it to remain active [6].

4.1. The NDV4-HR vaccine

The heat resistant V4 (NDV4-HR) vaccine against ND has yielded encouraging results in many countries in Africa [6] and Southeast Asia [7]. The NDV4-HR vaccine is a living vaccine with the following characteristics:

- it is thermostable, retaining its activity for 12 weeks at a temperature of 28°C in freeze-dried form [8];
- it can be administered via eye drop (intraocular), nose drop (intranasal), oral drench, or drinking water; mixed with certain feeds or by injection [7, 9];
- its ease of administration makes it suitable for use by village farmers;
- the vaccine strain can be transmitted by contact from vaccinated to non-vaccinated birds [7, 10];
- it is avirulent and can be safely administered to chickens of any age from day-old to adult [7, 9];
- its biological safety is superior to that of other living ND vaccine strains such as B1 or La Sota [9].

FAO recommends this vaccine for the control of Newcastle disease in village chickens in tropical countries and developing countries as a means of improving the food security of rural communities [11].

4.2. The ND I-2 vaccine

The Australian Centre for International Agricultural Research (ACIAR) commissioned workers at the Virus Laboratory in the University of Queensland to produce a seed virus similar to NDV4-HR that could be made available without cost to laboratories in developing countries [5]. Forty-five isolates of avirulent ND were examined for antigenicity, safety and ability to spread. The most promising of these isolates were checked for thermostability and the more resistant isolates selected for enhanced heat resistance. The result was strain I-2, which was amplified in eggs from a disease-free flock to form a master seed. The seed was tested for safety and for freedom from bacterial contamination.

Strain I-2 has undergone laboratory tests in several countries and has proved to be protective against local virulent strains of ND virus. In Vietnam it has been officially recognised as the ND vaccine for village chickens, after extensive laboratory and village trials [12]. In Tanzania it has given protection for at least two months after vaccination [13]. Results from field trials in Mozambique indicated that I-2 ND vaccine provided approximately 80% protection in the face of an outbreak, when given every 4 months via eye drop.

ND vaccine of acceptable standard can be produced from strain I-2 in central laboratories or even regional laboratories in developing countries. The vaccine can be produced in eggs, which are not specific-pathogen-free, but which come from a flock that is regularly screened for key poultry diseases. It can be produced and stored in liquid form, and suitably diluted in a protective solution such as 1% gelatin (in which the vaccine will maintain its activity for at least 12 weeks at 22°C) before use [5]. The thermostable vaccine is best administered via eye drop. The I-2 vaccine produced in Mozambique will retain its activity for 8 weeks at 28°C when in freeze-dried form and stored in the dark.

4.3. Storage and transport conditions for thermostable ND vaccines

If users have access to normal cold chain facilities, then by all means these should be used, even when dealing with a thermostable vaccine. A freeze-dried vaccine stored at 4–8°C will retain a high titre for a longer period than that stored at ambient temperature. At 4–8°C, the vaccine should maintain an adequate titre for at least one year.

When taking the vaccine to the field, it should be placed in a cool box with ice or an ice pack. The vaccine should not be frozen (unless the instructions specifically indicate that the vaccine may be

frozen). Freeze-dried vaccine packaged under vacuum rather than with nitrogen will lose the vacuum and gain moisture if the vial is frozen. The rubber cap on the vial contracts when frozen enabling moist air to enter the vial. When this occurs, the shelf-life of the vaccine is reduced.

Careful attention to the conservation of thermostable vaccines, once removed from refrigeration, will ensure optimal results:

- Always keep the vaccine away from sunlight.
- When transporting the vaccine in the field, wrap it in a damp cloth and carry it in a covered open-weave basket. This allows evaporative cooling which helps to keep the vaccine cool and the cover prevents contact with sunlight.
- Record the date the vaccine leaves the cold chain as it will remain effective for 2–3 months only.
- Store the vaccine in a cool, dark location, for example, near the base of a clay water pot.

4.4. Administration of thermostable live ND vaccines

Standard dose. As with other live ND vaccines such as La Sota, a minimum of 10^6 EID_{50}/bird is required to produce an adequate level of protection. EID_{50} (50% embryo infectious dose) is a laboratory measure of the content of living infectious virus in a vaccine. It has been demonstrated that birds that received a higher oral dose of the NDV4-HR vaccine generated a higher immune response when confined in cages with wire floors [4]. The same report indicated that the dose responsiveness to oral vaccination was no longer apparent when groups of vaccinated chickens were housed together on litter. The explanation for this result was that the vaccine virus replicated and was excreted in the faeces and the birds were then re-infected by the virus in the environment. This means that even though the thermostable vaccine can survive at ambient temperatures, attempts to improve its conservation will result in a slightly higher vaccine titre at the time of vaccination and, consequently, a higher and longer lasting immunity. This is particularly important when birds are not housed together at night.

Administration route. The vaccines can be administered via eye drop, drinking water, certain feeds and injection. Field trials in Mozambique indicated that almost all farmers preferred eye drop administration even though it required the capture of birds. In their opinion, eye drop administration of the vaccine produced a greater survival rate, had a lower frequency of administration and was easy. It is important to confirm that the eye-dropper to be used is made of virus-friendly plastic and that it is calibrated to ensure that one drop contains one dose. Calibration of the eye-dropper and administration of the eye drop to the bird is done with the dropper in a vertical position to make sure that drops of a uniform size are produced.

Age of bird. The same dose is given to birds of all ages, from day-old chicks to adults.

Vaccination schedule. For eye drop administration, the vaccine should be administered once, with re-vaccination every 3–4 months. Via drinking water, the vaccine should initially be given on two occasions, two to three weeks apart, with re-vaccination occurring at least every three months.

4.5. Dilution and use of thermostable live ND vaccines

The vaccines may be diluted using locally available potable water. It is recommended that the water is boiled and left to cool overnight in a non-metallic container before use. Chlorinated tap water is unsuitable. If, however, this is the only water available, let the treated tap water stand overnight to allow the chlorine to dissipate or add one teaspoon of powdered milk per 10 l of water to neutralise the effects of the chlorine.

Once the freeze-dried vaccine has been diluted, it is advisable to follow a simple schedule for eye drop administration:

* Day 1 ⇒ 1 drop per bird (i.e. first day of vaccination campaign)
* Day 2 ⇒ 2 drops per bird
* Day 3 ⇒ discard

4.6. Horizontal spread of thermostable live ND vaccine virus

The thermostable live ND vaccines spread from vaccinated to unvaccinated birds when housed together [4, 7, 10, 12]. The degree of spread under field conditions is less when birds roost in trees and horizontal transmission should not be seen as a reliable substitute for vaccinating village birds.

4.7. Safety issues

The avirulent live ND vaccines such as I-2 and NDV4-HR are unusual in that it is not possible to administer an overdose. They are harmless to both bird and handler. Both the I-2 and NDV4-HR vaccines produce no evidence of clinical respiratory signs, weight loss, mortality in young chickens or egg production drop after vaccination [5, 14]. The safety performance of the original V4 (avirulent) vaccine is superior to both the HB1 (lentogenic) and La Sota (mesogenic) vaccine strains (Table II).

TABLE II. COMPARATIVE SAFETY OF NEWCASTLE DISEASE VACCINE STRAINS [14]

Signs in vaccinated birds	Vaccine strain		
	V4	HB1	La Sota
Sneeze test	Nil	Definite signs	Pronounced signs
Respiratory disease	Nil	Clinical respiratory signs	Clinical respiratory signs
Weight gain	No effect	Significant reduction	Highly significant suppression
Mortality in young chickens	Nil	Yes	Yes
Egg production drop	Nil	5-10%	>10%

4.8. Genetic sequencing of thermostable live ND vaccines

Genetic analysis indicates a relationship between the chemical structure of limited areas of the genome of strains of ND virus and the virulence of these strains. An area of apparent importance is the cleavage site of the fusion protein on the surface of the virus particle. Particular amino acid patterns around the cleavage site in virulent strains have become known as the virulence sequence. V4 and I-2 and other vaccines such as La Sota and HB1 lack the virulence sequence.

4.9. Training

Thermostable ND vaccines can make an important contribution to the control of ND in areas where the cold chain is weak or non-existent. These same areas will frequently be characterised by a lack of infrastructure in general and low human resource capacity. In order to increase the success rate of ND control activities, adequate planning, organisation and training are prerequisites.

The necessary training will include short courses for key national and regional decision-makers, workshops for staff involved in the training of extension workers and community vaccinators, training sessions and refresher courses for front-line extension staff and community vaccinators. Components of the training should include the characteristics, handling and administration of the selected vaccine, how to organise a vaccination campaign and how to monitor progress.

4.10. Extension program

The extension program should seek to provide each group involved (from national to regional to village to household levels) in the implementation and monitoring of ND control activities with the information needed to make sound decisions and adequate plans. A comprehensive extension package should be developed for use with all available communication options, in particular, radio, newspapers, group meetings, field days, drama, school lessons, etc.

With regards to the vaccination of family poultry in particular, extension messages must be simple, clear and consistent [15]. The development of a successful ND control program requires close collaboration between those involved in the production and testing of the ND vaccine, field veterinary and extension staff and village chicken farmers. All involved must be willing to invest adequate time and resources in the development and evaluation of all aspects of the control campaign. Since women have had less access to western means of communication and often have more difficulty than men in interpreting material presented in western ways, it is essential that extension material is specifically pre-tested with both male and female farmers [16].

As with all field endeavours, it is best to start small and build on your success. In most cases, farmers will be expected to pay for the ND vaccine and so it is critical that the first vaccination campaign is a success. Most farmers will not grant you a second chance. The best way of ensuring good results is to prepare thoroughly before commencing with vaccinations in the field and to have the

will and the resources to ensure that subsequent campaigns will be implemented at the recommended intervals [6].

The front line extension staff must be encouraged to accompany the ND control activities and actively seek to identify other constraints that limit poultry production. Extension workers should collaborate with farmers in a process of continuous improvement. This process will also assist effective evaluation and monitoring of ND control activities.

4.11. Cost recovery and cost minimisation

For ND control activities to be sustainable in the long term, all costs associated with the production, distribution and use of the vaccine must be covered. In some instances, consumers (i.e. village chicken farmers) may be expected to cover all of the costs. In many cases, government agencies may subsidise some aspects of the control activities with the remainder being paid for by farmers.

Increasingly, government services are under pressure to privatise their services. Serious consideration must be given to whether or not the vaccination of village chickens is sufficiently lucrative to attract interest from the private sector. Perhaps the best option at present is the commercialisation of government services to ensure that the costs associated with ND control activities are paid for entirely or partially by the users. While this will require on-going government involvement in the activities in the short-to-medium term, the benefits to government are considerable. The resulting improved household production of village chickens will:

- Improve household food security – increased protein intake by children will decrease malnutrition and enable their mental capabilities to develop to their full potential, [17] thus ensuring a more productive working life.
- Improve household income – increased sales of chickens will enable families to resolve other problems such as the need for medicines, school fees, etc.
- Increase access to chickens in urban and peri-urban areas – once chicken traders identify areas where ND vaccination takes place regularly, they will choose to trade with chicken farmers in that location. Chicken traders also suffer huge financial losses due to ND mortality in chickens, particularly those traders who travel long distances to purchase chickens and are consequently forced to hold chickens for several days after purchase. If mortalities among purchased chickens decrease and the number of chickens available for purchase increases, the unit sale price of chickens should decrease. The chicken farmer will sell more birds and so make more money than was possible prior to the introduction of ND vaccination and the number of urban consumers who can afford to purchase chickens will increase as the unit sale price decreases.

Some governments or projects may wish to provide inputs such as ND vaccine free of charge. In such circumstances the emphasis needs to be on cost minimization rather than cost recovery. The main costs associated with the control of ND using locally produced I-2 vaccine are production costs, distribution costs and administration costs. With the production of freeze-dried vaccine, there must be a trade-off between the most cost-efficient number of doses of vaccine per vial and the number of doses that can realistically be used per day in the field. Where wet vaccine is produced, thought should be given to the most cost-efficient type of vials to be used to store the vaccine and reducing costs of administration of the vaccine. Community Livestock Workers with adequate training and supervision are likely to be the most cost-efficient means of administering the vaccine at village level.

5. CONCLUSION

The control of ND in village chickens is much more than the control of an animal disease. It can make a vital contribution to the improvement of household food security and poverty alleviation in many developing countries. The selection of an appropriate vaccine together with the implementation of comprehensive training, effective extension activities and cost-recovery will ensure that ND control activities are sustainable in the long term.

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