Livestock vaccination in India: an analysis of theory and practice among multiple stakeholders

This paper (No. 12122016-00091-EN) has been peer-reviewed, accepted, edited, and corrected by authors. It has not yet been formatted for printing. It will be published in December 2016 in issue **35** (3) of the *Scientific and Technical Review*

P. Rathod [(1)*], M. Chander [(1)] & Y. Bangar [(2)]

(1) Division of Extension Education, ICAR-Indian Veterinary Research Institute, Izatnagar-243122, Bareilly, Uttar Pradesh, India

(2) Division of Livestock Economics and Statistics, ICAR-Indian Veterinary Research Institute, Izatnagar-243122, Bareilly, Uttar Pradesh, India

* Corresponding author: prakashkumarkr@gmail.com

Summary

An effective and efficient disease prevention and control strategy is of paramount importance to improve the quality and quantity of livestock production in the Indian context. Although livestock vaccination is considered an emerging innovation of socio-economic importance in the Indian dairy industry, the rate of adoption and diffusion of vaccination technology is very low at field level. In this context, the authors examined the efforts of the Government of India to protect livestock health and control disease, considered the lessons learnt from rinderpest eradication, looked at field practices and the reality on the ground, and studied the perceptions of multiple stakeholders with regards to the relevance, profitability and sustainability of vaccination. In this study, the authors consider policy implications for the Indian dairy industry using the responses of 360 dairy farmers, 80 research scientists and 40 extension workers in India. The study revealed that scientists and extension experts rated vaccination highly in terms of its relevance, profitability and sustainability, while the perception of farmers was less favourable. The study also observed that, even after implementation of various disease control programmes with heavy financial expenditure, there was a wide gap between farmers and scientists and between farmers and extension workers with regards to their perceptions of the relevance, profitability and sustainability of vaccination, while the gap was very narrow between scientists and extension workers. It can be concluded, therefore, that there is a need to generate innovations for disease control that are perceived as relevant, profitable and sustainable so as to encourage higher levels of diffusion and adoption at field level. This study recommends that farmers partner with researchers and extension workers to ensure effective generation and transfer of new dairying technologies, leading to higher production and productivity in the Indian dairy sector.

Keywords

Profitability – Relevance – Sustainability – Vaccination.

Introduction

Dairying is an effective tool for rural development, employment and sustained income and it acts as an insurance against several risks (1), such as drought and income loss. However, although there are over 190 million cattle and more than 108 million buffaloes in India (2), productivity is very poor. For instance, the average annual milk yield of cattle is 1,172 kg, much less than that in New Zealand (3,343 kg), Australia (5,600 kg), the United Kingdom (UK) (7,101 kg), the United States of America (USA) (9,332 kg) orIsrael (10,214 kg) (3).Likewise, despite a significant increase in dairy production in India, per capita consumption of milk (69 kg) and meat (3.7 kg) has been much lower compared to the corresponding world averages of 85 kg and 40 kg, respectively (4). Thus, poor productivity as well as the quality of production and products remains a cause of concern in the Indian livestock and dairying sectors (5). These problems might be due to factors such as the lack of improved breeds and breeding services, lack of targeted preventive animal health care or good feeding strategies, and limited access to formal credit facilities (6). Among all these factors, poor livestock health resulting from multiple endemic diseases causes considerable economic losses to predominantly poor, marginal and landless farmers. An effective and efficient disease prevention and control strategy is, therefore, of paramount importance to mitigate these effects. Vaccination is considered to be the best strategy for disease control and for minimising economic losses due to diseases, but diffusion and adoption of vaccination technology at field level is very low (7). Since livestock vaccination is considered an emerging innovation of socio-economic importance in the Indian dairy industry (8), the authors carried out a study to examine the perception of multiple stakeholders, i.e. dairy farmers, scientists and extension workers, towards its use in India. Even after heavy financial investments and mass vaccination programmes, the adoption rate for vaccination continues to be poor in India owingto weak research and extension and poor linkages with farmers. With this theoretical background, the authors of the present study have examined the efforts of the Government of India to improve livestock health and disease control. They consider the lessons learnt from rinderpest eradication, look at field practices and the reality on the ground, and examine the perception of multiple stakeholders with regards to the relevance, profitability and sustainability of vaccination. Finally, they propose certain policy implications for the Indian dairy industry to improve livestock production and productivity.

Materials and methods

A mix of both primary and secondary data was used in the study, which involved dairy farmers, extension workers and university scientists from four states in north India. The veterinary universities and districts selected for study, which were purposively chosen for the objectives of the study, are presented in Table I. The authors used multistage random sampling and the snowball method to select 15 dairy farmers from each of the 24 villages included in the study, making a final sample size of 360 farmers. All the respondents selected for the study were male. As dairying is predominantly an adjunct to agriculture under mixed farming systems and is mainly carried out by smallholders who own only afew animals, care was taken to select farmers who reared at least two dairy animals. In the present study, 73.1% of the respondents had ‘agriculture with animal husbandry' as their major occupation, while only 5.3% of respondents said that 'animal husbandry'was their major occupation. The research scientists and extension workers included in the study were randomly selected. Care was taken to select 20 scientists and 10 extension workers from each university or allied *Krishi Vigyan Kendra* (Farm Science Centres), making a total of 80 scientists and 40 extension workers. Male and female participants were selected randomly: women represented 12.5% of scientists and 17.5% of extension workers.

The data from the dairy farmers were collected either at their farm or home using a pretested interview schedule, while data from the scientists and extension workers were collected personally at their work place using a questionnaire. The authors also collected information gained through observation during interviews and group discussions and from secondary sources such as departmental documents, records and reports. Furthermore, a workshop was organised for the scientists and scholars of the Indian Veterinary Research Institute (IVRI), Izatnagar, to discuss the issues and solicit various suggestions for effective generation and transfer of vaccination technologies (9). The scientists, extension workers and farmers were asked to provide their view of the relevance, profitability and sustainability of vaccination. For the question regarding relevance, they had the choice of three responses: 'relevant', 'irrelevant' or 'undecided'. Similarly, for profitability, they could choose between three answers: 'profitable', 'non-profitable' or 'undecided'. For the question about the sustainability of vaccination, the authors used the sustainability index of Swaminathan (10), with suitable modifications. The respondents were asked to consider 14 different dimensions of sustainability and indicate to what extent they agreed that vaccination met the criteria by assigning scores of 3, 2 or 1 for 'agree', 'undecided' and 'disagree', respectively. Farmers who did not see vaccination as sustainable had a less favourable opinion of it than those who saw it as highly sustainable, and respondents were categorised into 'low', 'medium' and 'high' favourability groups. The respondents were classified into three different categories for relevance, profitability and sustainability based on the mean and standard deviation. The data collected from sample respondents were coded, analysed and presented in the form of tables. The data were analysed using the SPSS software package, version 20.0, to determine frequency, percentage, mean, standard deviation, and Chi-square values. Inferences were drawn in light of the results obtained, keeping in view the study objectives.

Results and discussion

Status of livestock health and disease control in India

To effectively tackle the issue of livestock health and disease in India, the central government is supplementing the activities of the state governments through a centrally sponsored 'Livestock Health and Disease Control' scheme (11). Table II depicts the financial expenditure this incurred between 2009 and 2014. The major components of the scheme are as follows:

– Assistance to States for Control of Animal Diseases (ASCAD): Under this programme, from 2012 to 2013, approximately 342 million vaccinations were carried out, against a target of 190 million, and from 2013 to 2014, approximately 360 million vaccinations were administered, against a target of 250 million. Besides this, the programme also collects and compiles information on the incidence of various livestock diseases for the whole country. The information compiled is regularly notified to the World Organisation for Animal Health (OIE)

– National Project on Rinderpest Surveillance and Monitoring: Physical surveillance in villages and along stock routes, as well as institutional searches to detect any reoccurrence of rinderpest and contagious bovine pleuropneumonia (CBPP) are undertaken throughout the country to maintain India's freedom from these diseases. This physical surveillance is done with the help of staff of the Department of Animal Husbandry

– Foot and Mouth Disease Control Programme (FMD-CP): This location-specific programme is being implemented in 221 districts with 100% government funding to support vaccine purchase and its maintenance through the cold chain and to provide other logistical support for vaccine administration. During 2012–2013, approximately140 million vaccinations were carried out in the districts covered under the FMD-CP and about 97,000 (pre- and post-vaccination) serum samples were collected. During 2013–2014, approximately193 million vaccinations were administered, against a target of 155 million

– Establishment and Strengthening of Existing Veterinary Hospitals and Dispensaries: There are 10,901 veterinary hospitals/polyclinics and 22,402 veterinary dispensaries in India. To help the states set up infrastructure for new veterinary hospitals and dispensaries and to strengthen/equip the existing ones, the central government is providing funds on a 75:25 ratio, in which 75% is the centre share while 25% is the state share, except in north-eastern states, where the funds are allocated on a 90:10 basis

– Brucellosis Control Programme (Brucellosis-CP): This new component was started in 2010 and 100% government assistance is provided for mass vaccination of all female calves of 6–8 months in the high-incidence disease areas. Approximately 1.1 million vaccinations of eligible female calves have been carried out in different states of India under this programme

– Peste des Petits Ruminants Control Programme: This control programme, involving intensive vaccination of susceptible animals, was started in 2010 on the basis of 100% central government assistance. The programme involves vaccinating all susceptible goats and sheep and three subsequent generations. Under this programme, approximately 34 million vaccinations were carried out during 2012–2013 and approximately 25 million vaccinations were carried out during 2013–2014

– National Animal Disease Reporting System: This web-based information technology system has been implemented to streamline the system of animal disease reporting at field level. It is funded under a centrally sponsored scheme and has been implemented through the

National Informatics Centre. It is a system that reports the occurrence of animal disease data from block- and district-level veterinary units.

Along similar lines, Lubroth *et al.* (13) reported that vaccination campaigns must be part of comprehensive disease control programmes to be successful. The global management of high-impact animal diseases can be tackled through programmes which focus on controlling diseases at source (14).

Disease control programmes: lessons from global rinderpest eradication

Livestock diseases cause heavy losses in India and worldwide, including productivity losses resulting from morbidity (e.g. milk loss and a reduction in growth) as well as the loss of livestock. In this situation, the central and state governments are making great efforts to implement disease control programmes that also include livestock vaccination. Such programmes help in bench-marking progress in animal health care and disease control, leading to improved livestock production and productivity. Although regular efforts are made to control disease incidence, they are no substitute for an effective, timely and location-specific vaccination intervention. Further, given that the adoption of vaccination is poor at field level (7), the states should also undertake extensive livestock extension activities to educate farmers about the benefits of vaccination and its ability to control economic losses due to disease (15). In this context, the authors have made an effort to draw lessons from the successful worldwide eradication of rinderpest. The global eradication of rinderpest was possible due to the roles played by all stakeholders, including livestock owners, and this process can potentially be used for other diseases as well. Today, the lessons learnt can be applied to diseases such as peste des petits ruminants, FMD, CBPP and sheep and goat pox. To progress with FMD control, strengthening veterinary services and improving the prevention and control of other major diseases of livestock are essential. Intensive investigations into disease control must be carried out for small ruminants as well as larger livestock, taking into account the differences in sheep and goat husbandry practices and the agro-climatic conditions affecting the pattern of natural vegetation. These factors are indirectly influenced by socio-economic factors, the seasonal migration patterns of small ruminants, flock size and the population density of the animals. Such studies are only possible in collaboration with the state animal husbandry departments of respective regions and the cooperation of the local public (16). A major programme for the control of livestock diseases in large and small ruminants must be implemented immediately, with government funding and institutional coordination.

In the process of rinderpest eradication, most of the donor assistance came from the European Development Fund, the United Nations Development Programme and a number of individual countries, including Canada, Ireland, France, Italy, Germany, the UK and the USA, as well as the infected and at-risk countries (17). The Food and Agriculture Organization of the United Nations was also a substantial donor to rinderpest eradication, contributing more than US $45 million of its own funds over a 30-year period, mainly through its Technical Cooperation Programme (TCP) (17). Emergency TCP projects played a vital role in helping countries to counter new outbreaks of disease when other funding was less readily accessible. The European Union also played a substantial role in the eradication of the disease (18). Rinderpest was disastrous for the livestock sector in India, but the EU's strategy for developing political and economic relations with Asian countries includes providing support for animal health, and their assistance contributed greatly to the eradication effort. The EU has continued to implement projects to improve animal health and production in India, as this is a key component in promoting economic development and alleviating poverty. Project design is continually improving and, as a result, implementation becomes easier and substantial and sustainable outputs are achieved at project completion.

Dairy farmers' perceptions of vaccination

Even after various initiatives of the central and the state governments, the uptake of livestock vaccination at field level is dismal. This is despite the fact that 86.4% of the respondents believed that livestock vaccination was relevant to local production practices. It was interesting to note that more respondents from Haryana and Punjab perceived vaccination to be relevant compared to the respondents from Uttar Pradesh and Uttarakhand (Table III). With regards to the profitability of livestock vaccination, 61.4% of the farmers perceived vaccination as profitable at field level, while 32.8% were in the undecided category. However, this field study also showed that farmers had their livestock vaccinated only when a veterinarian or para-veterinarian visited their village under government schemes such as FMD-CP, Brucellosis-CP, etc. Table III shows that most farmers (63.9%) were in the 'medium' favourability category as regards the sustainability of vaccination, followed by 19.2% in the 'low' favourability category. There was a significant difference ($p < 0.001$) among the respondents across the states, which might be due to variations in the socio-economic conditions of the farmers and psychological factors such as their level of risk aversion and their understanding of the science behind vaccination. This variation in perceptions of sustainability might be due to the fact that farmers in Haryana and Punjab practised dairying on a commercial basis, which motivated them to implement vaccination. In a similar study conducted in Uttar Pradesh, Lal (19) reported that vaccination was more profitable and sustainable than artificial insemination. He also found that majority of the farmers were not familiar with the vaccination process and not aware that vaccinations were being carried out for certain diseases.

Scientists' perceptions of vaccination

The present study found that 96.9% of the scientists perceived vaccination as relevant, while the remaining scientists thought that vaccination was irrelevant at field level. Table IV shows that all the scientists in the study perceived vaccination as profitable under field conditions. Further, a few scientists also responded that livestock vaccination indirectly helped the farmers in maintaining healthy livestock for better production and productivity. Moreover, the study also found that, within the pooled data, 66.7% of the scientists were in the 'medium' favourability category for the sustainability of vaccination, followed by 21.2% in the 'high' sustainable category. A study conducted in Uttar Pradesh revealed that more scientists than livestock farmers perceived vaccination as profitable and sustainable (13).

Extension workers' perceptions of vaccination

The present study found that 95% of extension workers perceived vaccination as relevant to field conditions (Table V). Further, the study also reported that, within the pooled data, 95% of the extension workers considered vaccination to be profitable, while 5% were in the 'undecided' category. Further, the study also revealed that, within the pooled data, 52.2% of the extension experts were in the 'high' favourability category for sustainability followed by 47.8% in the 'medium' favourability sustainable category. This indicates that even the experts were not in agreement about the sustainability of livestock vaccination in field conditions.

Constraints or problems in adoption of vaccination, as perceived by farmers

The following are the major constraints or problems perceived by dairy farmers in practising vaccination for dairy animals under field conditions:

- lack of knowledge about vaccination
- vaccination reduces milk production
- vaccination causes infertility in animals
- swelling at the site of vaccination
- vaccination causes fever in animals
- reoccurrence of disease even after vaccination
- non-availability of veterinarians or skilled staff
- many times vaccinated animals are also disease affected
- poor infrastructure to store vaccines.

The results of the study as a whole revealed that linkages among the three stakeholders, i.e. farmers, scientists and extension workers were not strong enough, which is evident from the constraints or problems perceived by the farmers in adopting vaccination. In a similar study, Hefferman *et al.* (20) explored the low uptake of livestock vaccination among poor farming communities in Bolivia utilising core elements of the innovation diffusion theory. They found that vaccination behaviour was strongly linked to social and cultural, rather than economic, drivers.

Modifications/alternatives for effective transfer of vaccination

The modifications and/or alternatives suggested by dairy farmers for effective uptake of vaccination are listed below:

– inform farmers about the benefits of vaccination

– carry out the additional research required to study the causes of reduction in milk production post vaccination, if any, and find solutions to the problem

– investigate whether or not vaccination causes infertility in animals

– enquire why swelling at the site of vaccination occurs and how it can be controlled

– study the causes of fever in animals after vaccination

– investigate apparent vaccination failure, leading to reoccurrence of disease even after vaccination

– increase the number of veterinarians or skilled staff

– establish a reliable cold chain to store and transport vaccines

– store vaccines in refrigerators managed by the local village government associations (*Gram Panchayat*)

– carry out research to produce vaccines that can be stored at room temperature (thermostable/thermotolerant).

The results of the study revealed that farmers have various problems with the existing technologies and, therefore, they want modifications and support from various stakeholders, including research and extension institutes, government, etc. Farmers continuously generate and use knowledge in practice, and constantly experiment to manage risks and improve their operations. They should therefore be the natural partners of researchers (21), with whom they can participate in a mutual exchange of expertise and work towards combining modern and traditional knowledge in field conditions. In another study on deworming technology, Gray *et al.*(22) concluded that farmers, extension workers and scientists must jointly decide what technologies to try, what results mean and, if successful, how to sustain their use.

Differences in stakeholder perceptions of vaccination

The percentage gap among the various stakeholders, i.e. farmers, scientists (researchers) and extension workers, in their perceptions of vaccination is depicted in Table VI. The study reported that there was a 10.5% gap between the number of farmers and scientists who considered vaccination to be relevant. The gap between farmers and extension workers was 8.6%, while the gap between scientists and extension workers was very low, at just 1.9%. Thomas (23) reported that, for any research findings or new technologies to be perceived as relevant by farmers, there is a need to create a participatory approach to research and extension that emphasises the links between the two. Also, the approach must allow farmers to choose the technologies that are appropriate for them, thereby eliminating the perception that the extension system is separate from the research system. Table VI also shows that, in terms of perceptions of the profitability of vaccination, there was a wide percentage gap between farmers and scientists (38.6%) and between farmers and extension workers (33.6%), while the gap between scientists and extension workers was very low (5%). There was a wide percentage gap between farmers and scientists in the 'very high' (53.8%) and 'high' (29%) categories for sustainability, while the percentage gap between farmers and extension workers was 40.2% and 24.2% for the 'very high' and 'high' sustainable categories, respectively. A study conducted in Uttar Pradesh by Lal (19) also reported that scientists perceived vaccination as more sustainable compared to livestock farmers. This appears to confirm that the links between farmers, scientists and extension workers are weak. It is worth noting that poor links between farmers and extension workers are not just a problem for vaccination technology; Moran reported that poor acceptance rates by smallholders for feeding technologies was attributed, in part, to the lack of extension facilities (24). There is a need for a thorough evaluation of extension approaches in order to identify best practices, understand their impact on farming communities, and recognise how extension can be strengthened, particularly to reach smallholder and marginal farmers (25). In this context, Rathod *et al.* (15) point out how important it is that the Department of Animal Husbandry in each state implement widespread livestock extension activities to educate farmers about the benefits of vaccination and its ability to control economic losses due to the diseases.

Conclusion and policy implications

The perception of scientists and extension experts of vaccination is more favourable than that of farmers. A wide gap (higher percentage gap) exists between farmers and scientists and between farmers and extension workers with regards to perceptions of the relevance, profitability and sustainability of vaccination, while the gap is very narrow between scientists and extension workers. This highlights the fact that, although there is substantial investment by the Government of India in disease control and prevention (both in terms of finance and human resources), there is still quite poor diffusion and adoption of vaccination at field level. Developing countries, including India, should learn lessons from the global eradication of rinderpest, and apply similar strategies for the control of other diseases. Further, to increase the diffusion and adoption of new dairy innovations at field level, scientists have to create new technologies that farmers consider to be relevant, profitable and sustainable. The study recommends that farmers partner with researchers and extension workers to ensure the effective generation and transfer of new dairying technologies, leading to higher productivity in the Indian dairy sector.

Acknowledgements

The authors would like to express their sincere thanks to the Director of ICAR-Indian Veterinary Research Institute, Izatnagar, for providing the necessary facilities to conduct this research. They are also thankful to all the respondents for sharing their valuable views in the study. Finally, they would also like to thank the anonymous reviewers for their valuable comments and suggestions for improving the quality of this paper.

References

1. Prasad C.S. (2011). – Dairy production, quality control and marketing system in India. *In* Dairy production, quality control and marketing system in SAARC countries (S.K. Pal & N.A. Siddiky, eds). SAARC Agriculture Centre, Dhaka, 53–122. Available at: www.sac.org.bd/archives/publications/dpqc&ms.pdf (accessed on 17 July 2016).

2. Ministry of Agriculture (India) (2012). –19th Livestock Census. Department of Animal Husbandry Dairying and Fisheries, Ministry of Agriculture, New Delhi, 120 pp. Available at: http://dahd.nic.in/sites/default/files/Livestock%20%205.pdf (accessed on 17 July 2016).

3. Food and Agriculture Organization of the United Nations Statistics Department (2014). –FAOSTAT. Available at: http://faostat.fao.org/ (accessed on 20 July 2014).

4. Government of India (2012). – Report of the Working Group on Animal Husbandry and Dairying. 12th Five-year plan, 2012–2017. Planning Commission, New Delhi, 130 pp. Available at: http://planningcommission.gov.in/aboutus/committee/wrkgrp12/agri/AHD_REPORT_Final_rev.pdf (accessed on 29 November 2014).

5. Chander M., Dutt T., Ravikumar R.K. &Subrahmanyeswari B. (2010). – Livestock technology transfer service in India: a review. *Indian J. Anim. Sci.*, **80** (11), 1115–1125. Available at:

http://epubs.icar.org.in/ejournal/index.php/IJAnS/article/view/1907 (accessed on 13 July 2016).

6. Torsten H., Garcia O. & Saha A. (2003). – A review of milk production in India with particular emphasis on small-scale producers. Pro-Poor Livestock Policy Initiative (PPLPI) Working Paper No. 2, 58 pp. Available at: www.fao.org/ag/againfo/programmes/en/pplpi/docarc/wp2.pdf (accessed on 30 January 2015).

7. Rathod P., Hiremath S., Manjunathachar H.V., Balaraj B.L. & Bangar Y. (2014). – Adoption status of livestock innovations and factors affecting their adoption in Bidar district of Karnataka. *Indian J. Field Vets*, **9** (4), 62–65. Available at: www.indianjournals.com/ijor.aspx?target=ijor:ijfv&volume=9&issue=4&article=014 (accessed on 17 July 2016).

8. Rathod P. & Chander M. (2014). – Identification of socio-economically important dairy innovations in India: a perspective of scientists. *In* Facilitating information and innovations for empowering family farmers. Proc. First International Conference of the Asia and Pacific Islands Rural Advisory Services (APIRAS) and Fifth Congress of Extension and Education in Agriculture and Natural Resources Management (E. Karamidehkordi, ed.), 2–4 September 2014, University of Zanjan, Iran, 101. Available at: www.iaeea.ir/files/site1/Docs_documents/conference_farsi/5th_Congress/total_english_abstract_book.pdf (accessed on 14 January 2015).

9. Indian Veterinary Research Institute (2014). – Workshop on ‘Generation and transfer of livestock technologies: issues and strategies’, 29 November, Izatnager, India. Available at: http://ivri.nic.in/news/Workshop%20IVRI%20News.pdf (accessed on 30 December 2014).

10. Swaminathan M.S. (1991). – Toward sustainable agriculture: dimensions and components. *Employment News* (18–24 November 1991), New Delhi, **20** (34), 32.

11. Ministry of Agriculture (India) (2014). – Annual Report 2013–2014 of the Department of Animal Husbandry, Dairying and Fisheries. Ministry of Agriculture, New Delhi, 122 pp. Available at: http://dahd.nic.in/sites/default/files/FINAL%20ANIMAL%20AR%20 2013-14%20FOR%20WEB%20%20%204_0.pdf (accessed on 17 July 2016).

12. Ministry of Agriculture (India) (2010–2014). – Annual Reports for 2010–2014 of the Department of Animal Husbandry, Dairying and Fisheries. Ministry of Agriculture, New Delhi. Available at: http://dahd.nic.in/documents/reports (accessed on 17 July 2016).

13. Lubroth J., Rweyemamu M.M., Viljoen G., Diallo A., Dungu B. & Amanfu W. (2007). – Veterinary vaccines and their use in developing countries. *In* Animal vaccination – Part 1: development, production and use of vaccines (P.-P. Pastoret, M. Lombard & A.A. Schudel, eds). *Rev. Sci. Tech. Off. Int. Epiz.*, **26** (1), 179–201. doi:10.20506/rst.26.1.1737.

14. Rweyemamu M.M. & Astudillo V. (2002). – Global perspective for foot and mouth disease control. *In* Foot and mouth disease: facing the new dilemmas (G.R. Thomson, ed.). *Rev. Sci. Tech. Off. Int. Epiz.*, **21** (3), 765–773. doi:10.20506/rst.21.3.1378.

15. Rathod P., Chander M. & Desai B.A. (2013). – Vaccination strategy for prevention and control of economically important livestock diseases in Karnataka. *Indian J. of Field Vets*, **8** (4), 29–33. Available at: www.indianjournals.com/ijor.aspx?target=ijor:ijfv&volume=8&issue =4&article=007 (accessed on 17 July 2016).

16. Singh R.P., Saravanan P., Sreenivasa B.P., Singh R.K. & Bandyopadhyay S.K. (2004). – Prevalence and distribution of peste des petits ruminants virus infection in small ruminants in India. *Rev. Sci. Tech. Off. Int. Epiz.*, **23** (3), 807–819. doi:10.20506/rst.23.3.1522.

17. Food and Agriculture Organization of the United Nations (FAO) (2012). – Lessons learned from the eradication of rinderpest

for controlling other transboundary animal diseases. *In* Proc. of the GREP Symposium and High-Level Meeting, 12–15 October 2010, Rome. FAO Animal Production and Health Proceedings, No. 15, Rome. Available at: www.fao.org/docrep/016/i3042e/i3042e.pdf (accessed on 20 March 2015).

18. Food and Agriculture Organization of the United Nations (FAO) (1996). – The world without rinderpest. *In* Proc. of the FAO Technical Consultation on the Global Rinderpest Eradication Programme, 22–24 July, Rome. Available at: www.fao.org/docrep/003/w3246e/w3246e00.htm (accessed on 20 March 2015).

19. Lal N. (2000). – Sustainability of animal husbandry technologies. PhD Thesis. Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh.

20. Heffernan C., Thomson K. & Nielsen L. (2008). – Livestock vaccine adoption among poor farmers in Bolivia: remembering innovation diffusion theory. *Vaccine*, **26** (19), 2433–2442. doi:10.1016/j.vaccine.2008.02.045.

21. Smith O., Avila M. & Abdi N. (2004). – Strengthening linkages between farmers' organizations and agricultural research institutions. *In* Proc. of 36th World Farmers Congress of the International Federation of Agricultural Producers, 29 May to 4 June, Washington, DC, 1–11. Available at: www.fao.org/docs/eims/upload/210490/gfar%20paper%20for%2036wfc.pdf (accessed on 25 November 2015).

22. Gray G.D., Connell J.G. & Phimphachanhvongsod V. (2012). – Worms in smallholder livestock systems: technologies and practices that make a difference. *Vet. Parasitol.*, **186** (1–2), 124–131. doi:10.1016/j.vetpar.2011.11.056.

23. Thomas B. (2012). – An assessment of the role of research and extension services for small-scale crop farmers in North-Central Namibia. *J. Agric. Biodiversity Res.*, **1** (7), 122–126. Available at:

http://onlineresearchjournals.org/JABR/pdf/2012/dec/Thomas.pdf (accessed on 13 July 2016).

24. Moran J. (2014). – The feeding of by-products on small holder dairy farms in Asia and other tropical regions. *In* Final report of FAO E-Conference, November–December 2013, 47 pp. Available at: www.dairyasia.org/images/EconSynthPublishedfinal.pdf (accessed on 30 January 2015).

25. Glendenning C.J., Babu S. & Asenso-Okyere K. (2010). – Review of agricultural extension in India: are farmers' information needs being met? International Food Policy Research Institute (IFPRI) Discussion, Paper 01048. IFPRI, Washington, DC, 48 pp. Available at: http://cdm15738.contentdm.oclc.org/utils/getfile/collection/p15738coll2/id/7280/filename/7281.pdf (accessed on 31 December 2014).

Table I

Location of the study

Universities under study	Districts under study	States	Geographical location
ICAR-Indian Veterinary Research Institute, Izatnagar (http://ivri.nic.in)	Bareilly	Uttar Pradesh	28.36°N 79.41°E
G.B. Pant University of Agriculture and Technology, Pantnagar (www.gbpuat.ac.in)	UdhamSingh Nagar	Uttarakhand	28.98°N 79.40°E
ICAR-National Dairy Research Institute, Karnal (www.ndri.res.in/ndri/Design/Index.html)	Karnal	Haryana	29.69°N 76.98°E
Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana (www.gadvasu.in)	Ludhiana	Punjab	30.91°N 75.85°E

ICAR: Indian Council of Agricultural Research

Table II

Financial expenditure between2009 and2014

Source: Government of India Annual Reports, 2010–2014 (12)

Figures have been converted to United States Dollars and are expressed in thousands

Schemes/programmes	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014
Assistance to States for Control of Animal Diseases	15,847.5	12,235.5	10,620.0	13,227.0	13,387.5
National Project on Rinderpest Eradication	648.0	463.5	525.0	633.0	478.5
Professional Efficiency Development	637.5	523.5	679.5	720.0	760.5
Foot and Mouth Disease Control Programme	4,438.5	7,069.5	15,894.0	24,100.5	33,567.0
Strengthening of Existing Hospitals/Dispensaries	0.00	14,545.5	14,806.5	7,744.5	8,115.0
National Control Programme of PPR	0.00	4,108.5	496.5	765.0	687.0
National Control Programme of Brucellosis	0.00	1,230.0	1,773.0	901.5	637.5
National Animal Disease Reporting System	0.00	5,419.5	4,998.0	790.5	1,417.5
Livestock Health and Disease Control	21,571.5	45,595.5	49,792.5	48,880.5	59,050.5

PPR: peste des petits ruminants

Table III

Dairy farmers' perceptions of vaccination (*n* = 360)

Figures in parentheses indicate percentage

Variables	Categories	States				Pooled data	χ^2
		UP	UK	Haryana	Punjab		
Relevance	Irrelevant	6 (6.6)	3 (3.3)	0 (0)	0 (0)	9 (2.5)	20.7**
	Undecided	15 (16.7)	13 (14.4)	8 (8.9)	4 (4.4)	40 (11.1)	
	Relevant	69 (76.7)	74 (82.2)	82 (91.1)	86 (95.6)	311 (86.4)	
Profitability	Non-profitable	11 (12.2)	8 (8.9)	2 (2.2)	0 (0)	21 (5.8)	42.2**
	Undecided	43 (47.8)	34 (37.8)	23 (25.6)	18 (20)	118 (32.8)	
	Profitable	36 (40)	48 (53.3)	65 (72.2)	72 (80)	221 (61.4)	
Sustainability (favourability)	Low	60 (66.6)	9 (10)	0 (0)	0 (0)	69 (19.2)	228.5**
Mean ± S.D 31.04 ± 4.61	Medium	30 (33.3)	73 (81.1)	77 (85.6)	50 (55.6)	230 (63.9)	
	High	0 (0)	8 (8.9)	13 (14.4)	40 (44.4)	61 (16.9)	

UP: Uttar Pradesh

UK: Uttarakhand

Table IV

Scientists' perceptions of vaccination (*n* = 80)

Figures in parentheses indicate percentage

Variables	Categories	Universities				Pooled data	χ^2
		IVRI	GBPUAT	NDRI	GADVASU		
Relevance (*n* = 65) [(a)]	Irrelevant	0 (0)	1 (6.7)	1 (6.7)	0 (0)	2 (3)	2.40
	Undecided	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
	Relevant	18 (100)	14 (93.3)	14 (93.3)	17 (100)	63 (96.9)	
Profitability (*n* = 65)	Non-profitable	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	Nil
	Undecided	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
	Profitable	18 (100)	15 (100)	15 (100)	17 (100)	65 (100)	
Sustainability (*n* = 33) (favourability) Mean ± S.D 37.42 ±3.46	Low	1 (12.5)	2 (25)	0 (0)	1 (11.1)	4 (12.1)	3.7
	Medium	6 (75)	5 (62.5)	5 (62.5)	6 (66.7)	22 (66.7)	
	High	1 (12.5)	1 (12.5)	3 (37.5)	2 (22.2)	7 (21.2)	

a) The number of respondents that answered the question

GADVASU: Guru Angad Dev Veterinary and Animal Sciences University

GBPUAT: G.B. Pant University of Agriculture & Technology

IVRI: Indian Veterinary Research Institute

NDRI: National Dairy Research Institute

Table V

Extension workers' perceptions of vaccination (*n* = 40)

Figures in parentheses indicate percentage

Variables	Categories	Universities				Pooled data	χ^2
		IVRI	GBPUAT	NDRI	GADVASU		
Relevance (*n* = 40) [(a)]	Irrelevant	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6.3
	Undecided	0 (0)	2 (20)	0 (0)	0 (0)	2 (5)	
	Relevant	10 (100)	8 (80)	10 (100)	10 (100)	38 (95)	
Profitability (*n* = 40)	Non-profitable	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6.3
	Undecided	0 (0)	2 (20)	0 (0)	0 (0)	2 (5)	
	Profitable	10 (100)	8 (80)	10 (100)	10 (100)	38 (95)	
Sustainability (favourability) (*n* = 23) Mean ± S.D 36.52 ± 5.50	Low	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1.1
	Medium	4 (50)	3 (50)	1 (25)	3 (60)	11 (47.8)	
	High	4 (50)	3 (50)	3 (75)	2 (40)	12 (52.2)	

a) The number of respondents that answered the question

GADVASU: Guru Angad Dev Veterinary and Animal Sciences University

GBPUAT: G.B. Pant University of Agriculture & Technology

IVRI: Indian Veterinary Research Institute

NDRI: National Dairy Research Institute

Table VI
Differences (percentage gap) in perceptions of vaccination among different stakeholders

Variables	Categories	Percentage gap among the stakeholders		
		Farmers/scientists	Scientists/extension workers	Farmers/extension workers
Relevance	Irrelevant	0.6	3.07	2.5
	Undecided	11.1	5.0	6.11
	Relevant	10.5	1.93	8.61
Profitability	Non-profitable	5.8	0	5.83
	Undecided	32.8	5.0	27.78
	Profitable	38.6	5.0	33.61
Sustainability (favourability)	Low (14–21)	0.8	0	0.83
	Medium (22–28)	23.9	8.69	15.2
	High (29–35)	29.0	4.88	24.19
	Very high (36–42)	53.8	13.57	40.22