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Adoption status and factors influencing adoption of livestock vaccination in India: An application of multinomial logit model

PRAKASHKUMAR RATHOD[1] and MAHESH CHANDER[2]

ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh 243 122 India

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ABSTRACT

The present study highlighted the efforts of government of India for livestock health and disease control, adoption status of livestock vaccination technology, constraints as perceived by farmers and identified factors affecting adoption of vaccination in India using multinomial logit model. The primary data from 360 dairy farmers of 4 states in North India and secondary data from various sources were used for this purpose. The adoption status revealed that majority of the respondents partially adopted vaccination for more than 9 years, followed by adoption since 6–9 years depicting a highly significant difference among the respondents across the states. Multinomial logit model depicted the Chi-square value of 110.05 which showed that likelihood ratio statistics are highly significant suggesting that model was fit for explanation. The variables 'distance to veterinary institution' or 'animal healthcare centre' and livestock holding were significantly associated with the probability that the respondent will be a full adopter of vaccination. The study suggested that researchers and extension experts need to make farmers more aware about the benefits of vaccination. Further, the scientists have to analyze the problems of dairy farmers and find suitable solutions for higher diffusion and adoption at field conditions by participatory technology generation and transfer approach.

Key words: Adoption, Dairy innovation, Livestock technology, Livestock vaccination, Multinomial logit model

The scenario of livestock technologies adoption in developing countries, including India is very dismal, widening the gap between technologies developed and actually being adopted or used by the farmers. Although various technologies are generated and promoted by research institutions, only few of them are diffused and adopted effectively at field conditions. In a country like India, which is blessed with 190.09 million cattle and 108.7 million buffaloes (GOI 2012 a), the productivity *per se* is very poor. The average annual milk yield of Indian cattle is 1,172 kg, which is only about 50% of the global average (FAOSTAT 2014), and much less than New Zealand (3,343 kg), Australia (5,600 kg), UK (7,101 kg), US (9,332 kg) and Israel (10,214 kg). Likewise, despite a significant increase in dairy production, per capita consumption of milk (69 kg) and meat (3.7 kg) are much lower against corresponding world averages of 85 and 40 kg, respectively (GOI 2012 b). Further, Chander *et al.* (2010) also pointed out that poor productivity as well as the quality of production and products remain the cause of concern in Indian livestock and dairy sector.

Among various issues to be addressed, effective prevention and control of animal diseases is a critical element for improved livestock production and productivity. Over the years, various attempts were made to control livestock diseases by government in India and abroad to ensure that the incidence of animal diseases, especially those diseases that cause substantial economic losses for the poor, is reduced significantly. One of the major attempts in this direction was to diffuse and adopt livestock vaccination as a technology and practice it for significant transformations. Since, livestock vaccination was considered as a technology of socio-economic importance in India (Rathod and Chander 2014), various efforts were made by public and private extensions and research organizations for effective adoption and diffusion of vaccination, but still the adoption is very low at field conditions (Rathod *et al.* 2014). With this theoretical background, an effort was made to study the status of livestock diseases, efforts of the government of India for livestock health and disease control, study the adoption status of livestock vaccination technology, enlist constraints as perceived by farmers and also to identify factors affecting adoption of vaccination in India by multinomial logit model. Further, the study also proposed certain policy implications for Indian dairy industry to improve the diffusion and adoption of vaccination in India.

MATERIALS AND METHODS

Sampling: A combination of purposive and multi-stage random sampling was adopted in the study to select the

Present address: [1]Assistant Professor (prakashkumarkr @gmail.com), Dept. of Veterinary & A. H Extension, Veterinary College, Bidar, Karnataka. [2]Principal Scientist and Head (drmahesh.chander@gmail.com) Division of Extension Education.

respondents. Initially Agricultural / Veterinary Universities and Institutes (4), which are at the forefront of research in livestock sector, were selected (Table 1). All the selected Universities / Institutes have carried out researches in development of animal husbandry and dairying including vaccination. The districts in which these Veterinary Universities / Institutes are situated were thus selected to ascertain the extent of adoption of vaccination in dairying. Villages (6) from each district were selected randomly at the rate of 3 villages from each block. Farmers (15) having at least 2 dairy animals were then selected from each village using random snow ball method. Thus, the ultimate sample size comprised of 360 farmers from 24 villages in 4 states of North India.

Data collection: A judicial mix of both primary and secondary data was used in the study. The primary data was collected from the dairy farmers during November 2013 to June 2014 either at their farm or home using pre-tested interview schedule by personal interview method and also through an open schedule. Information through observation during interview, group discussion and secondary sources like departmental documents, records, reports and other sources were also collected.

Analytical framework: To ascertain the extent of livestock vaccination adoption in dairying, respondents were asked to elicit their adoption level on a 4-point continuum, viz. full adoption (3), partial adoption (2), discontinuation (1) and non adoption (0). Responses of the farmers regarding number of years for adoption of vaccination was categorized into respective categories, viz. adoption since last 0–3 years, adoption since last 3–6 years, adoption since last 6–9 years and adoption since more than 9 years. The data collected from sample respondents were coded, tabulated, analyzed and presented in the form of tables. Statistical tools, viz. frequency, percentage, mean, standard deviation and Chi-square test were used for analysis of the data using SPSS version 20.0 package. The inferences were drawn in light of the results obtained, keeping in view the objectives laid in the study.

Application of multinomial logit model to identify the factors influencing degree of livestock vaccination adoption: To identify the factors that influence the respondents' degree of adoption of vaccination, a multinomial logit model as used by Pundo and Fraser (2006), was fitted. The multinomial logit model not only focused on the most important decision (whether the farmer adopts vaccination or not), but also on the degree of adoption of vaccination. In the fitted model, the dependent variable assumed 3 discrete values, viz. 0 (when the respondent did not adopt vaccination), 1 (when the respondent partially adopted vaccination) and 2 (when the respondent fully adopted vaccination). Given the alternatives before a respondent, the probability that an individual chooses an alternative j, can be expressed by equation:

$$\frac{\Pr [Yi=j] = \exp (\beta' jXi)}{\Sigma \exp (\beta' jXj)} \quad \text{.....(1)}$$

where,

Pr[Yi=j], Probability that an individual i belongs to either 'No adoption', 'Partial adoption' and 'Full adoption' category; j, 1, 2, 3; i, 1, 2, 3, ….. , 360; Xi, vector of the predictor variables; and βj, vector of the estimated parameters.

The multinomial logit model determines the effect of independent variable on the probability that a farmer will belong to 1 of the 3 categories, viz. non-adopter, partial adopter and full adopter. This model was estimated by keeping the dependent variable 0 (i.e. non-adopter) as the reference category. The e^{β} was calculated, which gave the odds ratio (OR) associated with change in the independent variables. The odds mean the ratio of probability of happening of an event to probability of not happening of that event. The odds are expressed as single number to the ratio to 1. The odds of 2 associated with partial adoption, for example, means that the likelihood of partially adopting an innovation is twice that of not adopting. Zero-order correlation matrix was obtained to ensure that multi-collinearity did not pose any problem in estimating parameters of the mathematical model. The variables having higher multi-collinearity were dropped in the final model to improve the values of the variables. The variables used in the model with their expected signs are given in Table 2.

RESULTS AND DISCUSSION

Status of livestock diseases and efforts for its control in India: Livestock diseases cause heavy losses to livestock sector in India and globe. The maximum loss (49.83%) was

Table 1. Locale of the study

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

Table 2. Variables used in multinomial logit model and their expected signs

Variables	Definition and measurement	Expected sign
Age	Age of the respondent in years	±
Family size	Total number of members in a household	±
Land	Size of landholding of household in acres	±
Livestock	Number of livestock owned by the household in units	±
Distance	Average distance from veterinary institution or animal healthcare centre in kilometres	-
Information sources	Information seeking behaviour of the respondent from various sources on three point continuum as frequent, less frequent and never	±
Decision	Decision making ability of the respondent related to dairy farming on three point continuum as low, medium and high	±
Scientific	Scientific orientation of the respondent on three point continuum as low, medium and high	±
Economic	Economic orientation of the respondent on three point continuum as low, medium and high	±
Risk	Risk orientation of the respondent on three point continuum as low, medium and high	±
educnew=1	Illiteracy of the respondent	-
educnew=2	Education up to 10 years of education	±
ocupnew=1	Agriculture as major occupation and animal husbandry as subsidiary occupation of the household	±
ocupnew=2	Animal husbandry as major occupation of the household	±
partinew=1	No social participation of the respondents	-
partinew=2	Respondent is the member of at least one social organization	±

observed due to milk loss (direct and indirect), followed by opportunity cost (16.15%) and reduction in growth (12.20%) in India (Singh *et al*. 2013).

Table 3. Major animal disease outbreaks in India during 2009–10 to 2013–14

Diseases	2009–10	2010–11	2011–12	2012–13	2013–14
FMD	449	823	340	661	351
HS	354	272	344	301	130
BQ	294	322	369	413	176
Anthrax	68	47	60	33	24
Mastitis	NA*	116	135	186	106

NA*- Not available (GOI Annual Reports, 2010–2014).

Tables 3 and 4 depict the major animal diseases outbreaks and attack rates in India during 2009–10 to 2013–14 respectively, (GOI Annual Reports 2010–2014).

Table 4. Major animal diseases attack rates in India during 2009–10 to 2013–14

Diseases	2009–10	2010–11	2011–12	2012–13	2013–14
FMD	12324	24406	19715	12317	82930
HS	2428	3189	5309	2653	1637
BQ	883	1109	4707	2651	1606
Anthrax	400	209	504	165	99
Mastitis	NA*	24383	5789	9072	8990

NA*- Not available (GOI Annual Reports, 2010–2014).

In this situation, disease control programme, which also includes livestock vaccination programme is a great effort of central and state governments in India.

In order to effectively tackle the issue of livestock health and disease, the central government is supplementing the activities of the state governments by way of providing assistance through centrally sponsored scheme Livestock Health & Disease Control, with the increasing financial allocation (Fig. 1) and infrastructure development through establishment or upgradation of veterinary institutions (Fig. 2).

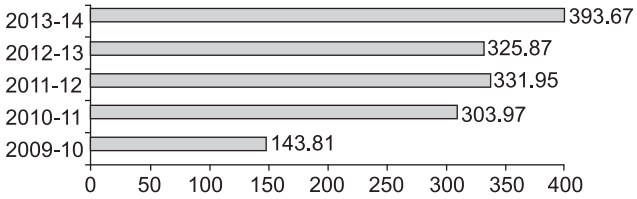

Fig. 1. Financial expenditure for livestock health and disease control in India during 2009–10 to 2013–14 (₹ in crores).
Source: GOI Annual Reports, 2010–2014.

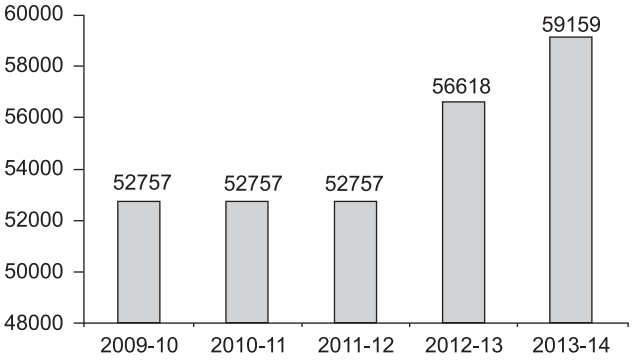

Fig. 2. Details of veterinary institutions in India during 2009–10 to 2013–14.
Source: GOI Annual Reports, 2010–2014.

Socio-personal, economic and psychological characters of dairy farmers: Majority of the dairy farmers (Table 5) in the study area from all the 4 states, viz. Uttar Pradesh, Uttarakhand, Haryana and Punjab belonged to medium age group ranging from 35 to 61 years of age and the average

age of dairy farmers was 48.20 years across all the states. The education status of the respondents revealed that majority of the dairy farmers in pooled data was illiterate followed by those having high school education. Further, majority of the respondents had agriculture as their main source of livelihood followed by about 12% of the respondents being labourers (Table 5). The pooled study also indicated that, majority of the respondents belonged to medium level of family size, land holding, herd size, experience in dairying and annual family income and that the majority of the farmers did not have any social participation and were mainly categorized under medium distance level veterinary institution or veterinary health care centre. Majority of the dairy farmers in the study area were in medium level of information seeking behaviour, decision making, scientific orientation, economic orientation and risk orientation. There was a highly significant difference among the respondents across the states with regards to all the studied variables except age and family size of the respondents (Table 5).

Table 5. Socio-personal, economic and psychological characters of dairy farmers (N=360)

Variables	Categories	Frequency (%)	Mean ± S.D	$\chi 2$
Age (in years)	Young	82 (22.78)	48.20 ±13.65	3.75
	Middle	206(57.22)		
	Old	72 (20.00)		
Major occupation	Agri +A H	263 (73.06)		31.8**
	A.H	19 (5.28)		
	Business	23 (6.39)		
	Govt. service	11 (3.05)		
	Labour	43 (11.94)		
	Any other	01 (0.28)		
Family size	Small	35 (9.72)	8.3±4.12	9.98
	Medium	285 (79.17)		
	Large	40 (11.11)		
Landholding	Landless	31 (08.61)	4.83±5.87	42.2**
	Small	68 (18.89)		
	Medium	226 (62.78)		
	High	35 (09.72)		
Livestock possession (in livestock units)	Low	07 (01.94)	4.59±3.55	25.0**
	Medium	303 (84.17)		
	High	50 (13.89)		
Social participation	Nil	178 (49.44)		63.4**
	One Org.	155 (43.06)		
	Two or more	24 (06.67)		
	Office bearer	0 (0)		
	Public leader	3 (0.83)		
Distance from veterinary institution	Low	75 (20.83)	4.27±5.05	187.7**
	Medium	255 (70.84)		
	High	30 (8.33)		
Information seeking behaviour	Low	69 (19.16)	19.37±1.92	56.3**
	Medium	237 (65.84)		
	High	54 (15.0)		
Decision making ability	Low	83 (23.06)	21.59±2.55	18.0**
	Medium	228 (63.33)		
	High	49 (13.61)		
Scientific orientation	Low	73 (20.28)	14.22±1.73	127.6**
	Medium	197 (54.72)		
	High	90 (25.0)		
Economic orientation	Low	77 (21.39)	12.94±1.72	83.7**
	Medium	206 (57.22)		
	High	77 (21.39)		
Risk orientation	Low	79 (21.94)	11.52±1.28	67.0**
	Medium	207 (57.50)		
	High	74 (20.56)		

Figures in the parenthesis indicate percentage; ***, significant at 1%, **, at 5% and *, at 10% levels of significance.

Adoption categories of livestock vaccination: The adoption status of livestock vaccination in the study is presented in Table 6. Among the pooled data, 62.78% of the respondents partially adopted vaccination, while 33.89% farmers fully adopted vaccination in their farm. It was considered partial adoption since in many instances, the farmers blindly vaccinated their livestock when the veterinarian visited their house but never realized its importance till date. They never contacted the veterinarian or an expert with the intention to vaccinate their livestock, which got deviated from the vaccination schedule. It was noted that there was a high significant difference ($P< 0.001$) among the respondents across the states with regards to adoption of vaccination, which might be due to variation of socio-economic status, risk and economic orientation and livestock holding. The higher adoption of vaccination may also be considered as the contributing factors for improved status of dairying in Punjab and Haryana. Almost similar findings with regards to adoption of vaccination were also reported by Rezvanfar (2007) and Basunathe *et al*. (2010) with regards to adoption of livestock vaccination.

Adoption status of livestock vaccination (years since when the practice was adopted): An attempt was made to study the total number of years since when vaccination was

Table 6. Adoption categories of livestock vaccination at field conditions

(N=360)

Categories	States				Pooled	$\chi 2$
	UP	UK	Haryana	Punjab		
Non-adoption	05 (5.56)	02 (2.22)	0(0)	0(0)	07 (1.94)	65.6**
Discontinuation	02 (2.22)	03 (3.33)	0(0)	0(0)	05 (1.39)	
Partial adoption	76 (84.44)	61 (67.78)	51 (56.67)	38 (42.22)	226 (62.78)	
Full adoption	7 (7.78)	24 (26.67)	39 (43.33)	52 (57.78)	122 (33.89)	

Figures in the parenthesis indicate percentage; ***, significant at 1%, **, at 5% and *, at 10% levels of significance.

Table 7. Adoption status of vaccination (since when vaccination was adopted)

(N=360)

Categories	States				Pooled	$\chi 2$
	UP	UK	Haryana	Punjab		
Non-adoption	05 (5.56)	02 (2.22)	0 (0)	0(0)	07 (1.94)	64.5**
0–3 years	02 (2.22)	02 (2.22)	01 (1.11)	0(0)	05(1.39)	
3–6 years	08 (8.89)	11 (12.22)	04 (4.44)	0(0)	23(6.39)	
6–9 years	38 (42.22)	34 (37.78)	28 (31.11)	10 (11.11)	110 (30.55)	
More than 9 years	37 (41.11)	41 (45.56)	57 (63.34)	80 (88.89)	215 (59.73)	

Figures in the parenthesis indicate percentage; ***, significant at 1%, **, at 5% and *, at 10% levels of significance.

adopted at the farmers' field (Table 7). The study also included the total number of years a farmer adopted vaccination even before discontinuing, if any. The study indicated that 59.73% of the respondents had adopted vaccination since more than 9 years, while 30.55% farmers adopted the innovation since, 6–9 years and 6.39% respondents were in the 3–6 year categories. Farmers in Haryana and Punjab adopted to the higher extent as compared to other states. This variation in the level of adoption might be attributed to socio-economic status, risk and economic orientation and information access in the study areas. This might be the reason for highly significant difference (P<0.001) among the respondents across the states with regards to adoption of vaccination in dairying. Rathod *et al*. (2014) and Musaba (2010) also reported similar findings in adoption of livestock vaccination.

Reasons for adoption of livestock vaccination

The reasons for adoption of vaccination as perceived by respondents have been enlisted.

- Have knowledge about benefits of vaccination
- Vaccination improves milk production in long run
- Animals are resistant to diseases
- Less disease occurrence in vaccinated animals
- Availability of veterinarians or skilled staff for vaccination
- Low/free charges for vaccination
- Follow the veterinarian without being aware of the benefits

The adoption studies of Rezvanfar (2007) and Rathod *et al*. (2014) observed almost similar findings with regards to adoption of vaccination at field conditions.

Reasons for partial adoption/ discontinuation and non-adoption of livestock vaccination

Following are the major reasons for partial adoption/ discontinuation or non-adoption of vaccination as perceived by the respondents in the study area.

- Lack of knowledge
- 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

Our results revealed that linkages among the 3 stakeholders, viz. farmers, researchers and extensionists were not strong enough which was clear with the constraints or problems faced by the farmers in adopting vaccination. Heffernan *et al.* (2008) explored the low uptake of livestock vaccination among poor farming communities in Bolivia utilising core elements of the original innovation diffusion theory. They found that vaccination behaviour was strongly linked to social and cultural, rather than economic drivers. Moran (2014) also reported that poor acceptance rate by the small farmers for majority of the technologies was attributed to the lack of extension facilities, unavailability of inputs and the time and labour involved under small farm situations.

Identifying factors influencing degree of vaccination adoption by application of multinomial logit model: To identify the factors that significantly influenced the respondents' likelihood of belonging to one of the different adopter categories of vaccination (viz. non-adopter, partial adopter and full adopter), a multinomial logit model was fitted, and the results are presented in Table 8. The Chi-square value of 110.05 showed that likelihood ratio statistics are highly significant (P<0.001) suggesting that model was fit for explanation.

The variables significantly associated with the probability that the respondent will be a full adopter of vaccination were 'distance to veterinary institution' or 'animal healthcare centre' (P<0.05) and 'livestock holding' (P<0.01). The signs of regression coefficients for the variables 'distance to veterinary institution' and livestock holding were negative and positive, respectively. The negative sign associated with the variable 'distance to veterinary institution' in case of full adoption indicated that as the distance to the veterinary institution increased, the probability of full adoption of vaccination decreased and that of partial and non-adoption increased. Greater distance from veterinary institution implied lesser chance of contact with livestock extension functionaries, which probably explained the negative association of distance from veterinary institution with higher degree of adoption of this innovation. The odds ratio associated with the variable distance to veterinary institution suggested that with one kilometre increase in distance from veterinary institution, the likelihood of full adoption of vaccination decreased by 78.8%.

Livestock holding of the farmers was positively associated with full adoption implying that with the increase

Table 8. Multinomial logit model for adoption of livestock vaccination

Variables	Partial adoption			Full adoption		
	B(S.E)	Wald	Odds ratio	B(S.E)	Wald	Odds ratio
Intercept	44.421(651.385)	0.005		40.06(651.385)	0.004	
Age	–0.026(0.032)	0.64	0.975	–0.036(0.033)	1.198	0.965
Family size	–0.165(0.112)	2.163	0.848	–0.172(0.113)	2.287	0.842
Land	–0.087(0.145)	0.358	0.917	–0.129(0.147)	0.77	0.879
Livestock	0.59(0.375)	2.468	1.804	0.608*(0.376)	2.612	1.838
Distance	–0.106(0.091)	1.346	0.9	–0.24**(0.097)	6.084	0.787
Information sources	0.275(0.429)	0.409	1.316	0.302(0.433)	0.487	1.353
Scientific	–0.415(0.439)	0.891	0.661	–0.092(0.447)	0.042	0.912
Economic	0.514(0.479)	1.149	1.671	0.61(0.484)	1.588	1.841
Risk	–0.082(0.633)	0.017	0.921	–0.175(0.639)	0.075	0.839
educnew=1	–15.805(651.277)	0.001	1.37E–07	–13.76(651.278)	0	1.06E–06
educnew=2	–0.764(735.686)	0	0.466	0.764(735.686)	0	2.146
ocupnew=1	1.155(1.35)	0.732	3.173	1.698(1.367)	1.542	5.464
ocupnew=2	–0.493(2.235)	0.049	0.611	0.048(2.274)	0	1.049
partinew=1	–12.491(1.899)	43.255	3.76E–06	–14.644(1.244)	138.501	4.37E–07
partinew=2	–13.494(1.455)	86.004	1.38E–06	–15.331(0)	.	2.20E–07

Figures within the parentheses indicate standard errors; ***, significant at 1%, **, at 5% and *, at 10% levels of significance.

Number of observations: 360; Wald chi^2:110.05; Prob > Chi^2: 0.0000; Pseudo R^2: Cox and Snell (0.26), Nagelkerke (0.33); Log pseudo likelihood: 462.34.

in livestock holding, the farmers moved towards increased adoption level. The odds of full adoption increased by 83.8% with an increase in one unit of livestock holding. In earlier studies, it was reported that number of contacts with extension officers, as a proxy measure for access to agricultural information, positively contributed to awareness and subsequent adoption of new technologies (Adesina *et al*. 2000, Yirga 2007).This also indicated that lesser contact with information sources and extension sources led to poor adoption of innovations. On the contrary, Heffernan *et al*. (2011) explored that uptake of livestock vaccination among poor farming communities in Tamil Nadu state of India was strongly influenced by socio-cultural grouping i.e. caste, rather than other factors such as income, age, education level and gender. Further, they revealed that adoption of livestock vaccination is unlikely to improve without knowledge transfer activities, which acknowledge both social divisions and local epistemologies regarding animal health.

The adoption status revealed that majority of the respondents partially adopted vaccination followed by full adoption in the study area. Majority of the respondents adopted vaccination since more than 9 years, followed by adoption since 6–9 years. There was a highly significant difference among the respondents across the states with regards to adoption of vaccination. Multinomial logit model depicted that the variables 'distance to veterinary institution' or 'animal healthcare centre' and 'livestock holding' were significantly associated with the probability that the respondent will be a full adopter of vaccination in the study area. The study suggests that researchers and extension experts need to make farmers more aware about the benefits of vaccination to improve productivity in the dairy sector. Since majority of the farmers were in partial adoption category, a need based long-run study under field conditions must be undertaken. Hence, the scientists have to analyze these problems and find suitable solutions for higher diffusion and adoption at field conditions through participatory technology generation and transfer approach based on the socio-economic background of the dairy farmers.

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