



Impact of vaccine against peste-des-petits ruminants (PPR) in India: An analysis using economic surplus model

D BARDHAN¹, R P SINGH², SANJAY KUMAR³, G ANANDASEKARAN⁴ and MOHD MERAJ⁵

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

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ABSTRACT

Peste-des-Petits Ruminants (PPR) as an acute contagious disease in sheep and goats has proved costly and is considered as one of the most important health constraints in rearing of small ruminants. ICAR-Indian Veterinary Research Institute, Izatnagar had developed a vaccine against the disease through research project during the period 1997–2001. The vaccine has been marketed by various agencies, both public and private since 2007–08 in many states of the country. The economic feasibility of PPR control programme using the above vaccine at the national level was estimated using an economic surplus model. The change in total economic surplus and research and delivery cost were projected from 1997 (year of the start of the research project) to 2030 (by which 100% of small ruminant population is to be vaccinated, as per OIE/FAO specifications) after adjusting for the above adoption pattern. The benefits to society (economic surplus) and costs of control programme were deflated using a suitable consumer price index to 2016 level. Using a long run discount rate of 7.5%, the benefits were compared to research and delivery cost and the NPV, IRR and BCR were calculated. The change in total surplus as a result of vaccination of sheep and goats against PPR was ₹ 8,253 crore per annum. The study revealed that the vaccination programme resulted into significant economic benefits (NPV= ₹ 489 crore). The IRR and BCR were 119% and 123:1, respectively. Sensitivity analysis revealed that the benefits were most sensitive to higher assumption of discount rate and lower assumption of degree of immunity provided by the vaccine accounting for uncertainties in the efficacy of the vaccine at the field level. In both the case, the net benefits decreased significantly. Net benefits to society also significantly decreased upon the assumption of declining adoption rates and ceiling adoption not reaching 100% level.

Key words: Economic surplus model, Goat, Impact assessment, PPR, Sheep, Vaccine

Peste des Petits Ruminants (PPR), commonly known as goat plague, is a highly contagious transboundary animal disease of small ruminants caused by a Morbillivirus, under the family Paramyxoviridae (Singh and Bandyopadhyay 2015). The disease is proving to be costly and is considered one of the most important health constraints in rearing of small ruminants. As per official figures reported by Department of Dairying, Animal Husbandry and Fisheries, Ministry of Agriculture, Government of India, PPR accounted for the highest proportion (62.71%) of incidences of all major important diseases in ovine/caprine population during 1995–2014 (Table 1). A recent study had estimated annual economic losses due to PPR at ₹ 8895 crores in India (Singh *et al.* 2014). Disease control/eradication activities require allocation of substantial amount of national

resources. Data regarding impacts of animal disease control measures are imperative for formulation of sound disease control policies from the economic point of view.

The major control measure available for eradication of PPR in sheep and goat is vaccination. ICAR-Indian Veterinary Research Institute (IVRI) had developed a live-attenuated vaccine as per Office-International-des-Epizootes (OIE) standards for the control of PPR. It has profound economic significance to India, other Asian countries and African continent. The vaccine is in great demand as Government of India has launched PPR control programme in alignment with the global movement of PPR control through Global PPR research alliance and other international agencies.

The present study attempts to quantify the impact of the vaccine in India using an economic surplus model.

MATERIALS AND METHODS

An economic surplus model (Alston *et al.* 1995) was used to measure the benefits of PPR control by vaccination as well as the benefits of and returns to research aimed at alleviating the disease. A static model of closed economy

Present address: ¹Senior Scientist (dwaipayanbardhan@gmail.com), ⁴Senior Research Fellow (dr.anandasekaran@gmail.com), ⁵Field Investigator (meraj.energy@gmail.com), Division of Livestock Economics, Statistics and Information Technology; ²Principal Scientist and Head (rpsingh@dr.com), Division of Biological Products; ³Principal Scientist and Incharge (sanjupandey01@gmail.com), ARIS/Computer Cell.

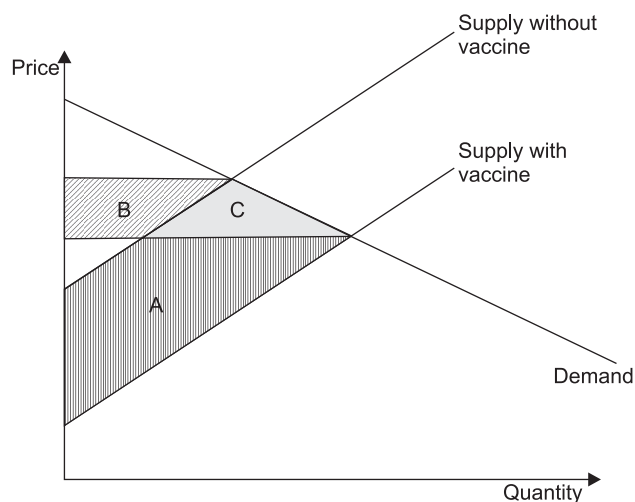


Fig. 1. Measuring change in total surplus.

was used in the analysis. Because the export of sheep and goat meat from India comprises only 2.31% of total meat exports in value terms (BAHS 2014), the increase in supply of meat as a result of control programme in the domestic market will reduce both the cost of the commodity to consumers and the price to producers. The simple case of linear supply and demand curves with parallel shifts was chosen.

In Fig. 1, gross annual research benefits are measured by the area between the two supply curves and beneath the demand curve. This area represents the total increase in economic welfare (change in total surplus) and comprises both the changes in producer and consumer surplus resulting from the shift in supply. Consumers are better off because

they consume more at a lower price. Although, producers are receiving a lower price for their meat, they are able to sell more, so their benefits increase. The algebraic derivations of these surpluses are shown in Table 2.

Supply and demand elasticities (ϵ , s): Demand and supply elasticities were both assumed as 1. The authors could not come across estimate of supply elasticity for sheep and goat meat through literature review in the Indian context. In literature available on economic surplus, earlier authors have suggested using unitary value of elasticities wherever such estimates are not available (Jones *et al.* 2006). Montes *et al.* (2008) had also used a supply elasticity of 1.0 for their assessment of impact of internal parasite control programme in Philippines. Estimates of demand elasticities are available in the Indian context (Kumar *et al.* 2009). However, although own price elasticity was calculated for milk, combined elasticity was computed for meat, egg and fish (-0.821). As such in this study, demand elasticity for sheep/goat meat was also considered as 1.

Measuring gross proportionate productivity gain per head ($E(Y)$): To measure gross proportionate productivity gain per head (sheep/goat), it was assumed that cent per cent vaccination of small ruminant population will remove the incidence of the disease. If disease induced productivity loss (both due to morbidity and mortality) is mitigated, then the avoided loss can be imputed as gain in productivity due to the technology (vaccine). To have an estimate of this avoided productivity loss, it is first required to have an estimate of number of cases and deaths due to PPR.

Considering the population of goats and sheep in the year 2012 (Livestock Census Report), the average annual morbidity rates due to PPR in India were 0.0039% and

Table 1. Year-wise number of incidence due to different diseases in sheep/goats

Year	FMD	Anthrax	Pox	Fasciolosis	Enterotoxaemia	PPR	CCP
1995	398	177	694	1941	1	2521	2518
1996	161	332	4597	2911	1325	926	298
1997	1508	515	2956	2030	1338	2354	1075
1998	4644	230	3997	2716	838	6339	312
1999	292	217	1027	1287	1612	13112	710
2000	387	125	3138	711	903	2132	186
2001	8393	305	5031	927	2904	23499	964
2002	3051	218	2299	791	911	4754	1139
2003	3673	348	4531	189	1722	22039	3223
2004	335	182	5954	74	1088	11389	309
2005	9572	231	14249	231	6562	44048	1067
2006	5345	408	19935	50	3974	28075	45
2007	5355	281	18261	213	6782	183238	163
2008	425	516	2279	53	2673	4496	405
2009	1720	1350	2006	144	1556	9271	0
2010	219	154	4009	101	1463	10188	1161
2011	485	197	3861	51	866	6976	22
2012	1577	127	2360	131	457	7281	1624
2013	4004	1546	913	254	392	4954	290
2014	794	302	2420	1701	1374	8216	29
	2616.9	388.05	5225.9	825.3	1937.1	19790.4	777.0
%	8.29	1.23	16.56	2.61	6.14	62.71	2.46

Table 2. Calculations of change in total surplus due to PPR vaccine

Parameter	Formula
Elasticity of supply	$\epsilon = [(\delta Q_s/Q_s) / (\delta P_s/P_s)]$
Elasticity of demand	$s = [(\delta Q_d/Q_d) / (\delta P_d/P_d)]$
Gross proportionate productivity gain per head (%)	$E(Y) = (Q_1 - Q_0)/Q_0$
Gross cost change per tonne (%)	$C = E(Y)/\epsilon$
Input cost change per head (%)	$E(c)$
Input cost change per tonne (%)	$i = E(c)/(1+E(Y))$
Net proportionate reduction in cost per tonne output (%)	$k = C - i$ $k' = k \times A^*$
Price (₹/tonne)	P
Quantity (tonnes)	Q_0
Relative reduction in price	$Z = k \times \epsilon / (\epsilon + s)$
Change in total surplus (₹)	$K \times P \times Q_0 (1 + (0.5 \times Z \times s))$
Change in consumer surplus (₹)	$Z \times P \times Q_0 (1 + (0.5 \times Z \times s))$
Change in producer surplus (₹)	$(k-Z) \times P \times Q_0 (1 + (0.5 \times Z \times s))$

* A is adoption rate.

0.0031%, respectively, on the basis of official figures as reported by Government of India. The mortality rates in these respective species were 9.21 and 6.75 per million of population. The above morbidity and mortality rates might be significantly low as it generally accepted that there is tendency for most of the countries to underreport the incidence of livestock diseases.

It was in this background that a need was felt to conduct an all-India study to ascertain the incidence rate of PPR in

sheep and goat. The following sampling procedure was adopted for this purpose. To ascertain the number of cases and deaths due to PPR, a household survey was carried out in different agro-climatic regions in India. Stratified multistage sampling technique was used for selecting the herds (ultimate sampling units). As per Planning Commission of India specification, India has 15 agro-climatic regions. This study covered 12 major agro-climatic regions of the country. From each agro-climatic zone, the state having highest small ruminant population was selected. The state of Uttar Pradesh, being the largest state in India, on the basis of geographical area, covers three agro-climatic zones, viz. upper and middle gangetic plain and central plateau and hills regions. For these regions, Uttar Pradesh was selected. From each selected state, two districts were selected, one having the highest sheep and goat population and another selected randomly. The agro-climatic region-wise states and districts selected are presented in Table 3. In the next stage, two blocks from each district and subsequently, 3 villages from each block were selected randomly. From each selected village, 20 farmers having at least one goat or sheep were selected as sample respondents. A total of 54,803 small ruminants were covered in the survey. Table 4 presents the number of sheep and goat surveyed in each agro-climatic region.

Identification of the disease is the most crucial issue in any survey on livestock disease incidence. For identifying the incidence of PPR, the method of indirect visual surveillance as given in FAO Animal Health Manual (Roder and Obi 1997) and participatory disease surveillance as reported by earlier authors (Hussain *et al.* 2008, Jost *et al.*

Table 3. Agro-climatic region wise selected districts

Region	State	District
Western himalayan region	Jammu and Kashmir	Bandipora Rajouri
Eastern himalayan region	Meghalaya	Western Garo Hills Western Khashi hills
Middle gangetic plain region	Uttar Pradesh	Behraich Bijnor
Upper gangetic plain region	Uttar Pradesh	Kheri Kaushambi
Trans gangetic plain region	Haryana	Bhiwani Hissar
Lower gangetic plains	West Bengal	Murshidabad Burdwan
Eastern plateau and hills region	Odisha	Mayurbhanj Keonjhar
Central plateau and hills region	Uttar Pradesh	Jalaun Banda
Western plateau and hills region	Maharashtra	Nashik AhmedNagar
Southern plateau and hills region	Tamil Nadu	Erode Namakkal
Gujarat plains and hills region	Gujarat	Kaach Banaskantha
Western dry region	Rajasthan	Barmer Bikaner

Table 4. Agro-climatic region-wise number of animals surveyed

Region	Breed	No. of animals surveyed	Total surveyed
Western himalayan region	Goat	3652	10517
	Sheep	6865	
Eastern himalayan region	Goat	218	226
	Sheep	8	
Middle gangetic plain region	Goat	876	1073
	Sheep	197	
Upper gangetic plain region	Goat	1408	1623
	Sheep	215	
Trans gangetic plain region	Goat	1751	6754
	Sheep	5003	
Lower gangetic plain	Goat	954	1080
	Sheep	126	
Eastern plateau and hills region	Goat	2222	2711
	Sheep	489	
Central plateau and hills region	Goat	323	555
	Sheep	232	
Western plateau and hills region	Goat	2304	4672
	Sheep	2368	
Southern plateau and hills region	Goat	1888	5246
	Sheep	3358	
Gujarat plains and hills region	Goat	6291	16798
	Sheep	10508	
Western dry region	Goat	1667	3547
	Sheep	1880	
Total	Goat	23554	54803
	Sheep	31249	

2010, Kihu *et al.* 2015) were adapted. This mostly consisted of relying on farmers’ recall to gain details of diseases that affected their herds. Focused group discussions were held in each selected village to understand how farmers identify different diseases that affect their animals and then rank these diseases in order of their importance. Then personal interviews were held with each selected farmer to collect detailed information on the disease, supported by an extensive checklist for disease identification based on clinical symptoms and photographs. The reference period for collecting the data was January 2015 to December 2015.

Based upon sample survey studies, morbidity and mortality rates in goats due to PPR were 11.51% and 4.36%, respectively. Imputing these rates on the goat population of the country (according to 19th Livestock Census 2012), the number of cases and deaths were worked out as 15558,412 and 5893,543, respectively. Assuming a live body weight loss of 20% for infected goats and average yield 11.01 kg for each goat (BAHS 2014), the gross productivity gain (in terms of live body weight) was worked out as 63.75% per head.

In case of sheep, based upon sample survey studies, morbidity and mortality rates due to PPR were 5.35% and 2.77%, respectively. Imputing these rates on the sheep population of the country (according to 19th Livestock Census 2012), the number of cases and deaths were worked out as 3481,192 and 1802,411, respectively. Assuming a

live body weight loss of 20% for infected sheep and average yield 13.36 kg for each sheep (BAHS 2014), the gross productivity gain (in terms of live body weight) was worked out as 43.90% per head.

Measuring input cost change per head (E(c)): The input cost change was accounted for by adding the cost of vaccine and vaccination to the cost of rearing a goat/sheep. Production cost of vaccine per dose as obtained from manufacturers was ₹ 1.50. Cost of vaccination (₹ 4.5/ vaccination) was arrived at based upon expert opinion. This per unit cost of vaccine and vaccination (₹ 6) was then imputed upon the population of sheep and goat in the country. Cost of rearing a goat per annum as given in various published works vary, ranging from ₹ 226 (Kumar *et al.* 2010) to ₹ 750 (Singh *et al.* 2013), depending upon the study area. For this study to find the proportionate change in per head cost, cost per annum for rearing a small ruminant was assumed as ₹ 500. The input cost change as a result of vaccination was then obtained as a proportion of this cost of rearing of small ruminant.

Measuring net proportionate reduction in cost (k): The research-induced supply-shift parameter, k, is the single most important parameter influencing total economic surplus results from unit cost reductions (Alene *et al.* 2009). k was estimated as per the formula given in Table 2. k’ was estimated by multiplying k with A, the adoption rate of the vaccine. k’ was finally used in the economic surplus model. Table 3 summarizes the assumptions for baseline analysis of returns to PPR vaccination.

Using the change in total economic surpluses as benefits and the research and delivery cost as costs of the control programme, following economic criteria were calculated to ascertain the economic feasibility of the vaccination process.

Net present value (NPV)

$$NPV = \sum_{t=1}^n B_n / (1+i)^n - \sum_{t=1}^n C_n / (1+i)^n$$

Benefit cost ratio (BCR)

$$BCR = \frac{\sum_{t=1}^n B_n / (1+i)^n}{\sum_{t=1}^n C_n / (1+i)^n}$$

where, B_n, year-wise benefits; C_n, year-wise costs; n, number of years (t=1 to n); and i, discount rate.

RESULTS AND DISCUSSION

Considering together all the categories and sub-categories of small ruminants, the overall annual morbidity and mortality rates in India were estimated from the sample as 8 and 3.45%, respectively (Table 4). In studies in outbreak areas in Southern Asia, very high morbidity and mortality

Table 3. Summary of assumptions for baseline analysis of potential returns to PPR vaccine research

Research period	: 1997-2001
Research costs	: Total ` 1,76,29,518 for the project period (1997-2001)*
Adoption period	: Vaccine marketed since 2007-08
Adoption rate	: 50% at present at All-India level (expert opinion)
Ceiling adoption rate	: As per OIE/FAO specifications, cent per cent vaccination is to be done by 2030. Government of India has set a target of achieving 90-100% vaccination by 2025.
Discount rate	: 6.5%
Cost of vaccine and vaccination**	: ` 6/dose

*Deflated at 2016 price level. **Production cost of vaccine per dose as obtained from manufacturers was ` 1.5/dose. Cost of vaccination based on expert opinion was ` 4.5/dose. The total cost of vaccination at All-India level was then obtained by multiplying the year-wise adoption rate with the corresponding goat and sheep population and the per dose vaccine and vaccination cost (` 6).

Table 4. Morbidity and mortality rates of PPR in animals surveyed

Particular	Morbidity rate (%)	Mortality rate (%)	CFR (%)
Goat	11.51	4.36	37.83
Sheep	5.35	2.77	51.89
Total	8.00	3.45	43.19

rates between 35 and 60% were reported in individual flocks (Majumder 1997, Shankar *et al.* 1998). However, in endemic areas it is understood that morbidities and mortalities are comparatively low (Roeder and Obi 1999). Morbidity and mortality rates as estimated in goats from the sample in this study were significantly higher than those of sheep. Earlier studies had also reported more pronounced severity of the disease in goats than in sheep (Awase 2012, Mahajan *et al.* 2013, Sahu 2013). Case fatality rate, on the other hand, was higher in sheep as compared to goats, indicating that although goats are more prone to pick up PPR infection, the disease is more inclined to be fatal in sheep once they are infected with the PPR virus.

The sources and values of parameters used in the economic surplus model in case of goats and sheep are presented in Table 5. The results of economic surplus model used to assess increase in societal welfare, as a result of vaccination of sheep and goats against PPR, by estimating change in total economic surplus are presented in Table 6. The change on total economic surplus, or total gains to the society was ` 82.53 hundred crore per annum. Greater economic surplus in case of goats (` 63.72 hundred crore) as compared to sheep (` 18.81 hundred crore) was both on account of higher morbidity and mortality rates in goats and higher population of goats in the country than sheep. Yield increase, as a result of vaccination, is mainly due to

Table 5. Sources and values of economic surplus input data

Parameter	Goat	Sheep	Source of information
Elasticity of supply (ϵ)	1	1	Assumed (Montes <i>et al.</i> 2008)
Elasticity of	-1	-1	Assumed (Montes <i>et al.</i> 2008)
Gross productivity proportionate gain per head (%) (E(Y))	63.75	43.90	Computed
Gross cost change per kg (%) (C)	63.75	43.90	Formula
Input cost change per head (%) (E(c))	1.50	1.50	Probable value
Input cost change per kg (%) (i)	0.01	0.01	Formula
Net proportionate reduction in cost per kg output (%) (k)	62.75	42.90	Formula
Price (` /kg) (P)	340	330	Field survey

Table 6. Results of economic surplus model: change in total surplus per annum ($\epsilon=1$, $s=1$)

Particular	Change in total surplus (` in 00 crore)
Goat	63.72
Sheep	18.81
Total	82.53

avoidance of body weight loss caused by morbidity and mortality due to the disease. As such, vaccination against PPR in goats is to provide much higher gain in the societal welfare, than in sheep. In this case of PPR control by vaccination, benefits to producers and consumers are same on account of unitary demand and supply elasticity assumption.

Impact of vaccination against PPR: The change in economic surplus and the research and delivery cost were projected to 2030, the year which is earmarked by Office-International-des-Epizootes (OIE) for achieving the target of PPR eradication. Several states in India have embarked in recent years on mass vaccination under large scale PPR control programme, targeting 100% of sheep and goat population. Overall, vaccination at all-India level as opined by experts at present is 50%, as several states are yet to implement vaccination coverage with a 100% vaccination target. Given the present level of 50% level of vaccination, it is assumed that vaccination rate will increase by 5% per annum till 100% coverage is achieved in 2025. The change in total economic surplus and research and delivery cost were projected from 1997 (year of the start of the project) to 2030 after adjusting for the above adoption pattern. The benefits to society (economic surplus) and costs of control programme were deflated using a suitable consumer price index to 2016 level. Using a long run discount rate of 7.5%,

Table 7. Impact of vaccine against PPR based on baseline assumptions

Particular	NPV (` in '00 crore)	IRR (%)	BCR
Goat	376.55	128	139.37
Sheep	112.60	104	88.23
Total	489.15	119	122.92

the benefits were compared to research and delivery cost and the NPV and BCR were calculated (Table 7). Overall, for both goats and sheep, the NPV and BCR were ` 489.15 hundred crores and 123:1, respectively. Internal rate of return (IRR) for control of PPR using the vaccine developed at ICAR-IVRI was calculated at 122.92%. Literature on application of economic surplus model in impact assessment pertaining to animal health is scant. Montes *et al.* (2008) had reported a BCR of 10.4:1 while assessing the impact of control programme of internal parasites in goats in Philippines. Kristjanson *et al.* (1999) had estimated a BCR of 34:1, based on baseline assumptions, in case of animal Trypanosomosis control in Africa. However, when assessing the sensitivity of the impact of the control programme under different assumptions pertaining to various parameters, the authors' estimates of BCR ranged from 16:1 to 77:1. However, it is to be noted that both the above control strategies were cost intensive. For example, in the case of controlling internal parasites in goats in Philippines, goat-

management technologies propagated included providing housing to animals, stall-feeding, rotational grazing, use of medicated urea-molasses mineral bricks to improve nutrition and use of anthelmintics. In case of control of trypanosomosis in Africa, the control strategies comprised of administering trypanocidal drugs along with pour-on control of insecticide for external parasite control. In the present case of PPR control, the technology are a simple process of vaccinating the animals only once a year without any capital investment. The benefits of successful vaccination are substantial as the incidence of disease is avoided which results in significant benefits to the society.

Sensitivity analysis: There can be variations in many of the assumptions while calculating the returns to PPR control programme, especially when the benefits and costs are projected in distant future. In this context, sensitivity analysis was carried out to ascertain the effect of changes in several of the baseline assumptions (Table 8). In the first scenario (conservative), it was assumed that the rate at which vaccination increases per annum was lower by 5% as compared to the baseline assumption. Further, in this scenario, it was also assumed that vaccination will not reach its 100% target and the ceiling vaccination level will remain at 80%. Given this scenario, NPV decreased by ` 49 hundred crore and IRR decreased to 119%. In an optimistic scenario, it was assumed that the rate of increase in vaccination per annum was 5% more and the 100% vaccination target is achieved 5 years earlier as compared to the baseline

Table 8. Sensitivity of estimated vaccine impact to assumptions

Assumption	Goat			Sheep			Total		
	NPV	IRR	BCR	NPV	IRR	BCR	NPV	IRR	BCR
<i>Conservative estimates regarding adoption</i>									
i. Adoption rate declines by 5% per annum as compared to baseline assumption	38.48 (-38.07)	128	137.29	101.84 (-10.76)	104	87.19	440.32 (-48.83)	119	121.14
ii. Ceiling adoption level is 80%									
<i>Optimistic estimates regarding adoption</i>									
i. Adoption rate increases by 5% per annum as compared to baseline assumption	395.15 (+18.06)	128	141.77	117.91 (5.31)	104	88.66	513.05 (+23.90)	119	123.67
ii. Ceiling adoption level of 100% reached 5 years earlier than baseline assumption									
Higher discount rate (10%)	226.60 (-149.95)	122	137.84	68.15 (-44.45)	100	87.05	294.76 (-194.39)	114	124.41
Vaccine affording 60% immunity	216.41 (-160.14)	116	80.52	65.28 (-47.32)	94	51.57	281.69 (-207.46)	108	71.21
Higher demand elasticity (s=2)	120.61 (-11.71)	364.84	128	135.07 (2.45)	115.05	104	90.12 (-9.26)	479.89	119
Higher supply and demand Elasticity (ε=2, s=2)	376.55 (0.00)	128	139.37	119.94 (7.34)	105	93.92	496.49 (7.34)	119	124.75
Cost per vaccination increases by 50%	375.30 (-1.25)	128	95.52	112.01 (-0.59)	104	60.58	487.31 (-1.84)	119	84.29

NPV, ` in hundred crore.* Figures in parentheses indicate changes in NPV from the baseline values.

assumption. In this case, the NPV increased by ` 24 hundred crore. This points towards the importance of intensifying vaccination efforts so as to achieve 100% vaccination coverage as early as possible. The discount rate chosen for the analysis was 7.55%. In a different scenario, a higher discount rate (10%) was adopted to ascertain the effect of higher discount rate on the benefits. It was assumed that high discount rate discourage investments with long term benefits (Kristjanson *et al.* 1999). At this higher discount rate, NPV declined by ` 194 hundred crore and IRR reduced to 114%. In the pessimistic scenario, assuming that the vaccine would provide immunity to 60% of animals, the benefits of the PPR control programme decreased by ` 207 hundred crore and the IRR and BCR decreased to 108% and 71:1, respectively. Under the assumption of demand elasticity equal to 2, to account for possibility of increased price sensitivity, the NPV decrease was marginal (by ` 9 hundred crore). Using both the demand and supply elasticities equal to 2 in the economic surplus model, the NPV increased by meagre ` 7 hundred crore. Accommodating for increase in vaccination cost by 50% did not have much impact on the impact of control programme as NPV declined only by about ` 2 hundred crore.

Peste des petits ruminants (PPR) is an acute contagious disease affecting goat and sheep population in the Indian subcontinent. Quantifying the economic losses from particular disease can provide some valuable indication towards the importance of the disease to the economy and also a measure of benefits to be gained from eliminating the disease. However, such information has to be supplemented with other information like what can be done about the condition, what the action costs, and its economic feasibility. The present study attempted to answer question this by assessing the impact of a vaccine developed at IVRI against PPR by using an economic surplus model. The findings of the study revealed significant benefits of PPR control programme using the vaccine. Sensitivity analysis revealed that the benefits were most sensitive to higher assumption of discount rate and lower assumption of degree of immunity provided by the vaccine accounting for uncertainties in the efficacy of the vaccine at the field level. In both the cases, the net benefits decreased. Net benefits to society also significantly decreased upon the assumption of declining adoption rates and ceiling adoption not reaching 100% level. This points towards the importance of mobilizing research-extension linkage to intensify the vaccination process and achieve full vaccination coverage at the earliest. The results of the model based on baseline assumption was lowest for changes in assumption in regard to demand and supply elasticities and increased cost of vaccination. Control of disease involves optimization of resource allocation decisions at national scale because the inputs it uses are scarce and have alternative uses. In this regard, it is expected that the findings of the study would provide valuable inputs towards formulating various livestock health intervention efforts.

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