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Estimation of Economic Losses due to Haemorrhagic Septicaemia in Cattle and Buffaloes in India§

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Abstract

In the present study, a methodology for the evaluation of economic losses due to Haemorrhagic Septicaemia has been developed by considering various possible direct and indirect losses in cattle and buffaloes. This methodology has been used to estimate the economic losses using survey data. It is revealed that the morbidity losses account for 23 per cent of the total losses and the rest (77 %) are due to mortality of the animals. Of the total morbidity losses, about half have been due to reduction in growth and one-fifth due to loss in milk. The total economic loss per infected animal due to Haemorrhagic Septicaemia has been estimated as ₹ 6816 in case of cattle and ₹ 10901 in buffalo. These losses when scaled-up at the national level have indicated a loss of ₹ 5255 crore. The direct losses contribute 80.3 per cent and indirect losses contributed 19.7 per cent to the total economic loss. The study has found that calves contribute 74.8 per cent and adults contribute 25.2 per cent to the total economic loss due to Haemorrhagic Septicaemia.

Key words: Haemorrhagic Septicaemia, economic loss, morbidity and mortality loss, opportunity costs

JEL Classification: Q10, Q12

Introduction

Haemorrhagic Septicaemia (HS) is a major bacterial disease of cattle and buffaloes. It is characterized by an acute and highly fatal septicaemia with high mortality rate (≈ 60%) and is prevalent throughout the country. Genetically, buffaloes are more susceptible to it than cattle and young animals are more prone to this than adults (FAO, 1991). There is a sharp drop in milk yield of the affected animals. It has emerged as a disease of considerable economic importance in India where cattle and buffaloes are large in number and are vital for milk production and draught power. It is the second most reported disease in India during 1991 to 2010 (NADRES- National Animal Diseases Referral Expert System) and is the cause of maximum number of the reported deaths. Around 97 per cent of the HS outbreaks reported by NADRES are in large ruminants (Gajendragad and Uma, 2012). Dutta *et al*. (1990) studied the epidemiological data of HS for a period of 13 years (1974-1986) and reported that HS was first in mortality and second in morbidity when compared to other epizootic diseases, namely foot and mouth disease (FMD), rinderpest, anthrax and black quarter.

In evaluation of economic losses due to a disease, the paucity of accurate data and information on the costs of animal disease and its control efforts makes decisions difficult on the most cost-effective interventions. It requires values of different parameters associated with the disease and its effect on production and reproduction traits. These values could be obtained through sample surveys or published information.

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However, the information on economic losses due to HS in India is scanty. Singh and Prasad (2008) have reported an average annual loss of ₹ 287.81 lakh due to HS in cattle in India based on the number of cases and deaths reported during 1991-2005 by the Department of Animal Husbandry, Dairying and Fisheries, Government of India. This loss might look small due to under-reporting of number of cases and deaths (Ahuja *et al*., 2008). This paper has attempted to develop a methodology for evaluating the economic losses due to HS in bovines considering the morbidity and mortality observed in the survey studies and all possible components of losses that may occur in bovines.

Data and Methodology

The secondary data on the number of cases (morbidity) and deaths were obtained from the *Annual Reports* of the Department of Animal Husbandry, Dairying and Fisheries, Government of India, for the past five years 2007-2011. To find the morbidity and mortality rates due to HS in bovines, the month-wise information on the number of cases and deaths was obtained from OIE website and was compiled according to regions and seasons (Summer: March to June; Rainy: July to October; and Winter: November to February). The primary data on the number of infected and died animals due to HS were collected through sample surveys conducted in the states of Himachal Pradesh, Madhya Pradesh, Maharashtra and Uttar Pradesh following the stratified multistage sampling during 2009 to 2012 (Shaikh, 2009; Bangar, 2011; Chaudhary, 2012 ; Dohare, 2011; Gupta, 2011; Sharma, 2012; Singh 2012).

The total economic loss due to HS in bovines was worked out as sum of the following components: (A) loss from mortality, (B) direct loss in milk yield, (C) losses due to reproductive failure in affected bovines, (D) loss in animal draught power, (E) reduction in growth of calf, (F) cost of treatment of the affected animals, and (G) Opportunity costs. Thus, the total economic loss (T_L) may be expressed as per Equation (1):

$$T_L = A + B + C + D + E + F + G \quad \ldots(1)$$

(A) Loss due to Mortality

It was worked out by multiplying the number of animals died with average price of an animal. The animals below 3 years were considered as calf (D_1) and of three years and above as adult (D_2). By taking their respective average prices as V_1 and V_2, the loss due to mortality can be expressed as per Equation (2) :

$$A = D_1 V_1 + D_2 V_2 \quad \ldots(2)$$

(B) Direct Loss in Milk Yield

For the proportion of sick animals in-milk in the herd, the losses are expressed in terms of reduced milk yield, which can be directly converted into the monetary loss by multiplying with the average milk price. The immediate fall in milk production in the lactating animals due to disease is rarely recovered and therefore milk loss is quite significant. The loss due to direct decline in milk production can be estimated by the formula (3) :

$$B = S\ P_L\ L\ Z\ M \quad \ldots(3)$$

where, S is the number of sick animals survived, P_L is the proportion of infected/sick animals in the herd (in lactation), L is the proportion of milk yield lost, Z is the average annual milk yield (kg), and M is the price of milk/kg.

(C) Losses due to Reproductive Failure

Besides causing substantial monetary loss through reduction in milk yield, HS remains a continuous threat to the dairy farming because of its effect on the reproductive capability of milch bovines. It results in abortion, especially in the later stages of pregnancy and also extends the calving interval of the affected animals. The losses in milk yield and monetary value of calves, which could have been born in the absence of disease, are to be worked out. The total loss (C) due to reproductive failure can be expressed as per Equation (4):

$$C = C_{11} + C_{12} + C_{21} + C_{22} \quad \ldots(4)$$

The components C_{11}, C_{12}, C_{21} and C_{22} are described below separately.

Losses due to Increased Abortions (C_1)

Milk Loss due to Abortions — If an abortion occurs after 7.5 months of conception and is followed by a delay of 6 months in the next conception, the calving interval is increased by 13.5 months and the milk loss due to increased abortions (C_{11}) can be estimated using Equation (5) :

$$C_{11} = \left\{ \frac{12}{C_I} - \frac{12}{C_I + 13.5} \right\} S\ P_L\ A_I\ Z\ M \quad \ldots(5)$$

Table 1. Treatment cost for Haemorrhagic Septicaemia-affected bovines

Item	Details
Antibiotic injection (i/m)	15 mL/ day 7 days, ₹ 100/-
Antipyretic injection (i/m)	10 mL/day × 3 days, ₹ 50/-
Vitamin B complex with liver extract	10 mL/day × 3 days, ₹ 50/-
Veterinarian visit charges	₹ 700/- for 7 days
Total	₹ 900

where, C_I is the calving interval, and A_I is the rate of increased abortions due to HS.

Value of Calves that Could Have Been Born (C_{12})

It was expressed by the relation (6):

$$C_{12} = \left\{\frac{12}{C_I} - \frac{12}{C_I+13.5}\right\} S\ P_L\ A_I\ V_C \quad \ldots (6)$$

where, V_C is the price of a new-born calf.

Losses due to Increased Calving Interval (C_2)

Milk Loss due to Infertility (C_{21}) — The problem of infertility caused by the disease is the lengthening of the calving interval, and therefore, a lesser number of animals will be in-milk at any given time. The effect of this problem is reduction in the output of milk. An average delay of 3 months in the next conception was assumed in the study for all the animals affected by the disease. The loss of milk is in the form of reduction in the proportion of animals lactating in any year and can be estimated by multiplying the average milk yield per year with the price (M), i.e.

$$C_{21} = \left\{\frac{12}{C_I} - \frac{12}{C_I+3}\right\} S\ P_L\ (1-A_I)\ Z\ M \quad \ldots(7)$$

Value of Calves that Could Have Been Born (C_{22})

It was calculated using the relation (8):

$$C_{22} = \left\{\frac{12}{C_I} - \frac{12}{C_I+3}\right\} S\ P_L\ (1-A_I)\ V_C \quad \ldots(8)$$

D. Loss due to Drop in Work Power

The HS causes significant losses to the farmers by reducing the availability of animals for ploughing, traction and other draught animal-led crop farm works. These losses can be worked out by using the formula (9):

$$D = S\ P_D\ D_W\ H_W \quad \ldots(9)$$

where, P_D is the proportion of infected draught animals, D_W is the number of days an animal does not work, and H_W is the per day hiring charges per animal.

(E) Loss due to Reduction in Calf Growth

The HS infection in livestock also results in retardation of growth rate in calf. This loss can be computed by the formula (10):

$$E = S\ P_C\ G_R\ V \quad \ldots(10)$$

where, P_C is the proportion of infected calf of age < 3 years, G_R is the reduction in growth rate, and V is the market value of adult animal.

(F) Cost on Treatment

One of the most immediate economic losses in HS-affected animals is the treatment cost which includes cost of medicines and fee to veterinarians. The treatment cost (T_C) is summarized in Table 1. The cost on treatment worked out by Equation (11) is given in Table 1.

$$F = S\ T_C \quad \ldots(11)$$

(G) Opportunity Costs

These costs are difficult to quantify because records and estimates on the costs of feeding, rearing, additional human labour for sick animals and disinfection of the shed are lacking. In the absence of any suitable data in this regard, these costs have been assumed as 5 per cent of the price of animals [Equation (12)] :

$$G = (S_1\ V_1 + S_2\ V_2)/20 \quad \ldots(12)$$

where, S_1 and S_2 are the number of survived animals below and above 3 years of age, respectively; and V_1 and V_2 represent their corresponding market prices.

Results and Discussion

Incidence of HS

During 2007 to 2011, the average number of HS-infected cases reported by the Department of Animal Husbandry, Dairying and Fisheries, Government of India, were 2416 in cattle and 825 in buffaloes (Table 2). The highest cases of cattle infection were reported from the eastern region (43.71%), followed by western (27.06%), southern (22.42%) and northern (6.81%) regions. The incidence pattern of HS in buffaloes was different; it was highest in southern region (69.93%), followed by northern (20.97%), western (8.51%) and eastern (0.58%) regions. In terms of the period, the effect of HS was observed throughout the year. Season-wise, the HS infection (number of cases) in cattle was more during rainy season (40.85%), followed by summer (30.6%) and winter (28.55%) seasons. In the case of buffaloes, the number of HS infection cases were more in the rainy season (64.65%), followed by winter (23.42%) and summer (11.93%) seasons. It showed that about 26 per cent cases occurred during the summer season in bovines in India.

Table 3.1 presents the average annual morbidity and mortality rates of HS during 2007 to 2011. These rates were 12.14 per million and 3.40 per million, respectively in the cattle and 7.83 per million and 3.30 per million, respectively in buffaloes. The estimated incidences of morbidity as well as mortality are quite low during 2007-2011 than during 1974-1986 (Dutta *et al*., 1990). The rates reported by the Government of India are low perhaps due to under- reporting. The data compiled from various official sources are most likely a significant underestimate of the disease incidence due

Table 2. Region-wise and season-wise average numbers of cases and deaths due to Haemorrhagic Septicaemia in bovines during 2007-2011

Animal species	Region*	Summer		Rainy		Winter		Total		Percentage	
		Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Cattle	East	509.8	38.2	328.2	166	218.2	31.4	1056.2	235.6	43.71	34.82
	West	60.4	21.4	329.2	94	264.2	33.4	653.8	148.8	27.06	21.99
	North	33	14.4	94.6	29.8	37	7.8	164.6	52	6.81	7.69
	South	136.2	53	235	106.6	170.6	80.6	541.8	240.2	22.42	35.5
	Total	739.4	127	987	396.4	690	153.2	2416.4	676.6	100	100
	Percentage	30.6	18.77	40.85	58.59	28.55	22.64	100	100		
Buffalo	East	0	0	4.8	3.2	0	0	4.8	3.2	0.58	0.92
	West	3.6	3.2	35	24	31.6	13.4	70.2	40.6	8.51	11.69
	North	14.8	2.2	91.4	16.8	66.8	3	173	22	20.97	6.34
	South	80	42.4	402	196	94.8	43	576.8	281.4	69.93	81.05
	Total	98.4	47.8	533.2	240	193.2	59.4	824.8	347.2	100	100
	Percentage	11.93	13.77	64.65	69.12	23.42	17.11	100	100		

Source: Compiled from OIE website

*Regional classification:

West: Gujarat, Maharashtra, Rajasthan, Goa, Lakshadweep

East: Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Tripura, West Bengal, Odisha

North: Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Jharkhand

South: Andhra Pradesh, Karnataka, Tamil Nadu, Pondicherry

Table 3.1. Average morbidity, mortality and CF rates due to Haemorrhagic Septicaemia during 2007-2011

Species	Population (in lakhs) (2007)	Average number of animals		Morbidity per million	Mortality per million	CFR (%)
		Infected	Died			
Cattle	1990.75	2416	677	12.14	3.40	28.00
Buffalo	1053.43	825	347	7.83	3.30	42.10

Source: Basic Animal Husbandary Statistics, Govt. of India (various issues)

Table 3.2. Number of infected and died animals due to Haemorrhagic Septicaemia based on survey studies, 2007-2011

Animal species	Total		Infected animals		Died animals	
	Infected	Died	Below 3 years (86%)	Above 3 years (14%)	Below 3 years (85%)	Above 3 years (15%)
Cattle	1413433	811028	1215552	197881	689374	121654
Buffalo	1703396	964633	1464921	238475	819938	144695

Source: Compiled from the M.V.Sc. thesis of the students of Biostatistics discipline
*IR : Buffalo, 1.62 per cent; Cattle, 0.71 per cent; and CFR : Buffalo, 56.63 per cent; Cattle, 57.38 per cent

to severe under-reporting and non-reporting of outbreaks. Part of this under/non-reporting is due to poor diagnostic capacity at the field level, but a significant part is due to administrative apathy and poor design of reporting system (Ahuja *et al*., 2008).

The results from the surveys (Table 3.2) in selected states have revealed that morbidity and mortality rates were 0.90 per cent and 0.55 per cent, respectively in cattle and 2.68 per cent and 1.90 per cent, respectively in buffaloes. The case fatality rate (ratio of number of deaths to the number of cases) of HS was 28.08 per cent in cattle and 42.87 per cent in buffaloes as per Government of India data, but the corresponding figures based on survey studies were 57.38 per cent and 56.63 per cent. In the epidemiological studies conducted during 1995-98 by Verma *et al*. (2004), low prevalence of HS has been observed in buffaloes (0.31%) and cattle (0.25%), but high case fatality rate (CFR) was high at 58.90 per cent and 38.94 per cent, respectively. Sharma *et al.* (2007) have observed 2.85 per cent morbidity with 0.69 per cent mortality and 24.27 per cent case fatality rate during July, 2003 to June, 2005 in 22 outbreaks of HS in bovines in Haryana.

Economic Losses due to HS

To illustrate the application of developed methodology, the component–wise and species- wise economic losses due to HS were evaluated considering morbidity and mortality rates observed in survey studies (Table 5) and the probable values of parameters presented in Table 4. Among different components of

Table 4. Probable estimates of parameters for Haemorrhagic Septicaemia effects in bovines

Parameters	Notation	Cattle	Buffalo	Source of information
Proportion of sick animals in lactation (%)	P_L	0.10	0.12	
Average annual milk yield (kg)	Z	1500	1800	BAHS (2012), Planning Commission (2007)
Average market value of animal (₹)	V	V_1 =15000 V_2= 25000	V_1=25000 V_2=45000	Probable value*
Increased abortion rate (%)	A_I	5	5	Probable value
Proportion of lactation lost (%)	L	0.20	0.20	Probable value
Calving interval (months)	C_I	20	20	Singh and Lal (1991) & AICRP reports
Price of milk (₹)	M	30	40	Probable value
Delay in next conception (months)	W	3	3	Probable value
Price of new born calf (₹)	V_C	3000	5000	Probable value
Proportion of draught animals in herd (%)	P_D	0.05	0.03	BAHS (2012)
Proportion of calf of age less than 3 years (%)	P_C	0.85	0.85	BAHS (2012)
Reduction in growth (%)	G_R	15	15	Probable value
Number of days animal could not work	D_W	60	60	Probable value
Per day hiring charges of draught animals (₹)	H_W	200	200	Probable value
Treatment cost of a survived animal (₹)	T_{CS}	900	900	Probable value

Note: *Close approximation to possible true value as per the suggestion of subject experts.

Table 5. Component-wise annual economic losses due to Haemorrhagic Septicaemia based on survey studies

(in lakh ₹)

Component of losses	Cattle	Buffaloes	Total	Loss (%)
(A) Loss due to mortality				
Calves	103406	204984	308390	
Adults	30413	65113	95526	
Total mortality loss	133819	270097	403916	76.86
(B) Morbidity losses				
(i) Milk loss				
Direct loss	5422	12766	18188	3.46
Increased abortions	328	771	1099	0.21
Elongated calving interval	2015	4746	6761	1.29
Total milk loss	7765	18283	26048	4.96
(ii) Value of calves				
Increased abortions	26	54	80	0.02
Elongated calving interval	134	329	463	0.09
Total value of calves	160	383	543	0.10
(iii) Drop in work power	3614	2660	6274	1.19
(iv) Reduction in growth	19202	42386	61588	11.72
(v) Treatment cost				
Calves	4736	5805	10541	
Adult	686	844	1530	
Total treatment cost	5422	6649	12071	2.30
(vi) Opportunity cost				
Calves	3946	8062	12008	
Adults	953	2110	3063	
Total opportunity cost	4899	10172	15071	2.87
Loss due to morbidity	41062	80533	121595	23.14
Total economic loss	174881	350630	525511	
Percentage loss (%)	33.28	66.72		
Morbidity loss per survived animal (₹)	6816	10901		

losses, the maximum loss of 76.86 per cent was observed due to mortality and 23.14 per cent due to morbidity in bovines. Among different components of morbidity losses, the highest loss was due to reduction in growth (11.72%), followed by milk loss (4.96%), opportunities cost (2.87%), treatment cost (2.30%) and drop in work power (1.19%). The other components of losses were: increased abortions, elongated calving interval, and total value of the calves that could have been born, but these contributed marginally to the total economic loss due to HS in bovines in India.

In cattle, the mortality losses due to HS were about 76.52 per cent and the rest 23.48 per cent were by morbidity. In buffaloes, the mortality losses were 77.03 per cent and the rest 22.97 per cent losses were due to morbidity. The morbidity loss per survived cattle and buffalo was ₹ 6816 and ₹ 10901, respectively. It is estimated that there was an annual loss of ₹ 5255.11 crore due to HS in bovines (Table 5). Verma *et al*. (2004) have estimated the annual economic loss to be around ₹ 58 million due to HS in buffaloes in Haryana.

Table 6. Direct and indirect economic losses due to Haemorrhagic Septicaemia in India

(in lakh ₹)

Component of losses	Cattle	Buffaloes	Total	Loss (%)
		Direct loss		
Mortality loss	133819	270097	403916	95.69
Milk loss	5422	12766	18188	4.31
Total direct loss	139241	282863	422104	100
Contribution to total loss (%)				80.32
		Indirect loss		
(i) Milk Loss				
Increased abortions	328	771	1099	
Increased calving interval	2015	4746	6761	
Total milk loss	2343	5517	7860	7.60
(ii) Value of calves				
Increased abortions	26	54	80	
Elongated calving interval	134	329	463	
Total value of calves	160	383	543	0.53
(iii) Drop in work power	3614	2660	6274	6.07
(iv) Reduction in growth	19202	42386	61588	59.56
(v) Total treatment cost	5422	6649	12071	11.67
(vi) Total opportunity cost	4899	10172	15071	14.57
Total indirect loss	35640	67767	103407	100
Contribution to total loss (%)				19.68

The total economic loss due to HS can be divided into two parts (i) direct losses, and (ii) indirect losses. Direct economic loss is due to mortality and reduction in milk output due to HS. The contribution of direct losses to the total economic losses was 80.32 per cent. The morality loss contributed 95.69 per cent, whereas milk loss contributed 4.31 per cent to total direct loss. The major components of indirect economic losses were: milk loss due to increased abortions and elongation of calving interval, the value of calves that could have been born, reduction in growth, reduction in work power, cost on animal treatment and the opportunity cost. The contribution of indirect loss to the total economic losses was 19.68 per cent. Among different components of indirect losses, the contribution was highest of reduction in growth (59.56%), followed by opportunity cost (14.57%), treatment cost (11.67%), total milk loss (7.60%), drop in work power (6.07%) and values of the calves (0.53%) (Table 6).

Based on the age groups of the animals, the economic losses due to HS can be divided into two groups: (i) calves, and (ii) adults. In the case of calves, the maximum loss was due to mortality (78.46%), followed by reduction in growth (15.67%), opportunity cost (3.05%), treatment cost (2.68%), and total value of calves (0.14%). The calves contributed 74.80 per cent to the total economic loss. In the case of adults, the mortality loss contributed 72.13 per cent to total economic loss in adults, followed by total milk loss (19.67%), drop in work power (4.74%), opportunity cost (2.31%) and treatment cost (1.15%). The adults contributed 25.20 per cent to the total economic loss (Table 7).

Conclusions and Policy Implication

The study has revealed that the morbidity losses account for 23 per cent of the total losses and the rest

Table 7. Animals age group-wise losses due to Haemorrhagic Septicaemia

(in lakh ₹)

Component of losses	Cattle	Buffaloes	Total	Loss (%)
(A) Losses in calf (less than 3 years)				
(i) Mortality loss	103406	204984	308390	78.46
(ii) Value of calves				
Increased abortions	26	54	80	
Elongated calving interval	134	329	463	
Total value of calves	160	383	543	0.14
(iii) Reduction in growth	19202	42386	61588	15.67
(iv) Treatment cost	4736	5805	10541	2.68
(v) Opportunity cost	3946	8062	12008	3.05
Total loss in calves	131450	261620	393070	100
Contribution to total loss (%)				74.80
(B) Loss in adults (> 3 years)				
(i) Morbidity losses	30413	65113	95526	72.13
(ii) Milk loss				
Direct loss	5422	12766	18188	
Increased abortions	328	771	1099	
Elongated calving interval	2015	4746	6761	
Total milk loss	7765	18283	26048	19.67
(iii) Drop in work power	3614	2660	6274	4.74
(iv) Treatment cost	686	844	1530	1.15
(v) Opportunity cost	953	2110	3063	2.31
Total loss in adults	43431	89010	132441	100
Contribution to total loss (%)				25.20

(77 %) are due to mortality of the animals. The total economic loss per infected animal due to Haemorrhagic Septiceamia has been estimated as ₹ 6816 in the case of cattle and ₹ 10901 in buffalo. Based on the survey, it has been estimated that HS causes economic loss of ₹ 5255 crore in India. The direct losses contribute 80.32 per cent and indirect losses 19.7 per cent to the total economic loss. The contribution of calves has been found 74.8 per cent and of adults 25.2 per cent to the total economic loss due to Haemorrhagic Septicaemia. The study has revealed significant losses due to incidence of HS in cattle and buffaloes in India. Thus, HS should be considered as an important disease from the policy perspective when it comes to mitigating losses due to diseases in dairy animals. This involves investment in research on HS and implementation of vaccination schedules as a preventive measure.

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