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Impact of recent outbreak of lumpy skin disease on Northern dairy dominant areas in Bangladesh

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ABSTRACT

The study is an attempt to measure the loss of farmers due to the outbreak of lumpy skin disease in Bangladesh. To accomplish the objectives, primary data were collected from 369 farmers of northern districts (Sirajganj, Nilphamari, Rangpur and Dinajpur). Multistage and purposive sampling technique was followed for selecting the respondents those who have only faced LSD in their livestock farms. A good number of cross breed cow in all four districts, of which 72%, 15%, 15% and 71% were affected in LSD in Dinajpur, Nilphamari, Sirajganj and Rangpur, respectively. Average herd size of milking cows before outbreak for local breed was 2.06 of which average affected number of cows was 1.52 and for cross breed the values were 4.46 and 1.94. No farm animal has found died in Nilphamari district. In Sirajganj, 4 claves and 2 young animals died. In Dinajpur, 20 calves had died while in Rangpur, 15 calves, 5 young animals and 3 adult animals found died due to LSD attack. Average milk loss has been estimated as 12% and 13% for local and cross bred farms respectively while the losses are 31%, 7%, 30% and 9% for Dinajpur, Nilphamari, Rangpur and Sirajganj, respectively. Per cow direct cost is the highest in Sirajganj (Taka 6389) and lowest in Dinajpur (Taka 1500). Per cow indirect cost is highest in Rangpur (Taka 2473) and lowest in Nilphamari (taka 1304). Highest per cow economic loss is found in Sirajganj (taka 8622) and lowest in Nilphamari (taka 3185). If the epidemic continues for longer from 20 days to 25, 30, 35 and 40 days, then the total economic loss can be increased by 100%.

INTRODUCTION

Animal diseases represent threats to the environment, animal welfare, public health, and the economy. Livestock diseases contribute to losses via increased mortality, reduced productivity, control costs, loss in trade, decreased market value, and food insecurity. The economic and social impacts of livestock disease have been recognized globally, in both developed and developing countries (Barratt et al., 2019). Quantifying the economic impact of an animal disease outbreak is important in support of prevention and control decisions for improved animal health. While direct disease costs are important, indirect costs are also of concern because the costs of disease do not stop at the farm-gate, within the agricultural sector, or after disease freedom is declared. Disease can affect a wide range of sectors of the economy. However, few studies evaluate the full economic cost of disease outbreaks. Often only farm costs are considered and indirect impacts are not included. There is a danger that estimates of economic costs of animal disease fail to capture indirect costs and may underestimate the true costs of an outbreak. It is important to understand the full economic cost of animal disease outbreaks and to achieve this, economic disease cost frameworks must include indirect costs. This is essential to support holistic decision-making of disease prevention and control strategies because producers and policymakers need to be aware of the broader disease impacts to improve animal health welfare strategies and policy. This will be particularly important if alternative policy options lead to significantly different indirect cost outcomes and hence different decision choices than would otherwise be indicated.Lumpy skin disease (LSD) is a highly infectious viral disease upsetting cattle, caused by

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LSD virus (LSDV) within the family Poxviridae, characterized by the appearance of skin nodules (Abdullah et al 2018). The World Organization for Animal Health (OIE) categorizes LSD as a notifiable disease because of the substantial economic impact and rapid transboundary spreading in nature (Tuppurainen et al., 2012). It is mainly spread through mosquitoes, flies, and ticks.LSD causes considerable economic losses due to emaciation, hide damage, temporary or permanent infertility in males and females, abortion, mastitis and mortality of up to 40%, although mortality rarely exceeds 3% (Gumbe et al., 2018). The disease impacts heavily on cattle production and milk yields. An affected cow can go from producing 20 litres a day to 2 litres a day. Poor, small-scale, and backyard farmers are often hit hardest. For a long time, the virus was restricted to sub-Saharan Africa. Over the past decades, however, it has slowly invaded new territories. In August 2015, the first LSD cases in mainland Europe were observed in Greece in the Evros region at the European border (Agianniotaki et al., 2017). The first outbreak in Bangladesh was reported to the Department of Livestock Services in July 2019. More than half a million cattle in Bangladesh are thought to have been affected. There is still no treatment for Lumpy Skin Disease. Large-scale vaccination is the most effective way to limit the spread of the disease (FAO, 2020).

On December 22, 2019, The Dhaka Tribune published that, the disease had spread to all corners of Faridpur district. Cattle farmers were scratching their heads at the sudden outbreak of lumpy skin disease affecting the livestock over the last two and a half months in the district. According to the Department of Livestock Service, the infection rate increased suddenly in the district, forcing worried owners to sit together to find out ways to tackle the situation. Within that period, the disease has affected 4,195 cattle and killed 10 cows in the district. With more and more cows were becoming affected by an outbreak of lumpy skin disease (LSD), cattle farmers in Bhola were becoming increasingly worried for their cattle. According to the Department of Livestock Services (DLS), there were a total of 595,020 cows in the district as of August 2019 and the Bangladesh Livestock Research Institute had been instructed to supply vaccines among local farmers to promptly counter the viral disease. Milk from those cattle farm had little demand to those who were aware of the condition of some of the cows (The Dhaka Tribune, November 26, 2019). On May 16, 2020, The Business Standard reported that hundreds of cattle in various villages in Kendua and Nandail Upazilas of Netrokona had been suffering from a lumpy disease, making farmers anxious about their animals (The Business Standard, May 16, 2020).

On November 26, 2019, bdnews24 published that LSD has spread in different Upazillas of Chattogram. The Financial Express has published on June 18, 2020 that Sadar, Khansama and Bochaganj Upazilas of Dinajpur district have recently been an outbreak of lumpy skin disease in cattle. In total, more than half a million cattle in Bangladesh were thought to have been affected. There is no treatment for Lumpy Skin Disease. Large-scale vaccination is the most effective way to limit the spread of the disease.

On Jun 18, 2020, The Daily Star published that at least 50 cattle, mostly calves, have died and nearly 20,000 infected with lumpy skin disease in seven out of eight districts in the Rangpur division over the last several months. Thakurgaon so far saw the highest number of deaths, 15, and 2,000 infections; Kurigram 7 deaths and 3,000 infections; Dinajpur 5 deaths and 3,000 infections; Nilphamari 4 deaths and 2,000 infections; and Lalmonirhat 2 deaths and 2,000 infections. Rangpur and Gaibandha districts had 3,100 and 420 infections respectively with no incidents of death. There was neither any infection nor any death relating to LSD in the Panchagarh district. In a news report published in the paper on June 10, headlined 'Lumpy skin disease virus killing cattle in Saidpur: Farmers say they lost as many as 20 cattle in a couple of months' of which are mostly calves, died of "secondary infection" of LSD. Based on the situation mentioned above, the study aimed to measure the direct costs (economic costs) of lumpy skin disease (LSD) by livestock keepers in Northern Bangladesh and to measure the indirect costs of lumpy skin disease (LSD) by livestock keepers in order to formulate policy recommendation.

METHODOLOGY

Study area and sampling

To accomplish the objectives, the research collected primary and secondary data. Primary data were collected from 369 farmers of northern districts (Sirajganj, Nilphamari, Rangpur and Dinajpur). Multistage and purposive sampling technique was followed for selecting the respondents who have only faced LSD in their livestock farms. At first, we collected the list of affected farmers from the DLS or ULO offices and then collected data from the dairy farmers through face-to-face interview methods using a pre-tested interview schedule.

Table 1: Number of farms selected (district-wise)

Districts	Dinajpur	Nilphamari	Rangpur	Sirajganj	Total
No. of farms	102	88	89	100	369
Upazilas	Kaharol, Biral	Saidpur Upazila	Sadar, Mithapukur	Shahajadpur	
Breed type	Only local	Only cross	Both	Farms without affected dairy cattle	
No. of farms	44	260	53	12	369

From the 369 samples, we interviewed 102, 88, 89 and 100 farmers from Dinajpur, Nilphamari, Rangpur and Sirajganj Upazila respectively where 44 of them kept only local breed, 260 farmers only cross breed, 53 farmers were mixed local and cross bred and there were 12 farmers, of whom other than dairy cows were affected like fattening cows. In case of cross-bred, we found, only two types: Holstein friesian and Shahiwal. Holstein friesian can give up to 20 liters of milk and Shahiwal can give a maximum 8-10 liters of milk. Shahiwal cows give milk starting from 4 liters to 8-10 liters of milk. About 80% of our data of cross breed cow is Holstein friesian and 15-20% Shahiwal. Holstein friesian initially gives 5-6 liters of milk and in some areas, there are some cows can give up to 26-28 liters of milk. Gradually the production of the breed increases. In addition, we have conducted 10 in-depth interviews to know their loss and indirect costs of dairy farming, which we could not measure.

Analytical technique

In this study, epidemiological model results were integrated with an economic model to enable estimation of the economic impacts of outbreaks of lumpy skin disease. Two types of cost were measured here, which are direct and indirect disease costs. Direct disease costs are the costs that include animal disease, including animal mortality, morbidity, and associated response costs. On the other hand, indirect costs were defined as the economic losses incurred in markets after disease freedom was declared (Barratt et al., 2019). To assess these costs, we used the model developed by Mclnerney (1996).

Structural Design of the Model

The direct disease cost is a function of loss and expenditure. Here loss means the loss of productivity and expenditure refers to the cost of prevention and cure of a specific disease. So, the mathematical expression would be,

$C = (L+E)$ (1)

A more simplified framework is as follows (Bennett, 2003):

$C = (L+R) +T+P$ (2)

Where,

L = Loss of expected output due to the disease

R = Increase in expenditure on non-veterinary resources such as labour, feed cost etc.

T = cost of input used in the treatment of the disease

P = cost of disease prevention measures

Basically, R, T, P are the components of expenditure, E. All of these components have to be measured separately though L and R are considered and will calculate separately.

These components can be measured as follows:

$L = p\ i_d\ i_e\ e\ v_l$

$T = p\ i_t\ v_t$

$P = p\ i_p v_p$
Here,
p: size of livestock population at risk (000s)
i_d: annual incidence of disease as a proportion of the population at risk
i_e: incidence of disease effects as a proportion of the affected population
e: magnitude of physical disease effects (e.g., litres of milk lost)
v_l: unit value of lost output or resource wastage (e.g., £s/litre of milk lost)
i_t: proportion of population at risk treated
v_t: cost of treatment per animal
i_p : proportion of population at risk where prevention measures taken
v_p : cost of prevention measure per animal

Indirect cost estimation

The indirect costs, i.e., the economic losses incurred in markets after disease freedom is declared, associated with an LSD outbreak in the Northern Region were estimated by integrating output from the IRF elasticities and epidemiological model (i.e., the number of animals culled inputs into the indirect costs time series model).

The indirect costs are associated with price and quantity changes, i.e., change in revenue or revenue foregone, in each market, i, as a result of a supply shock of animals culled, j, after disease freedom is declared:

$$ICs= 1(Pi,d*Q,d)-(Pi,t*Qi,t) \quad (5)$$

Where i denotes commodity 'milk', and j represents cow culled. Pi and Qi are the price and quantity in the ith commodity market, respectively. t denotes the period before the outbreak and d is the period after disease freedom is declared until the supply shock dissipates.

We collected all the data related to this model to assess the direct cost of LSD along with some other data related to indirect cost. Further, with all the data a simplified spreadsheet was made by following the Mclnerney (1996) model using Microsoft Excel. All the data were analyzed using STATA 20.

In this study, epidemiological model results will be integrated with an economic model to enable estimation of the economic impacts of outbreaks of lumpy skin disease.

Calculation of Wealth index

The wealth index is a proxy of household income data. Since the income data is a little bit confidential, so we have used this tool to analyze the household socio-economic condition. There are different ways to measure wealth index but income, expenditure, and consumption are the three main components in every way. Several variables were included in each component and these variables may vary in different socio-economic contexts. To calculate the wealth index for this study, we have considered three types of household asset such as productive asset, non-productive asset and household utility and others. After choosing these variables, a binary transformation was made to all of them. Improve or good quality household utility got value 1, otherwise 0. Having productive and non-productive assets also assigned a value with 1 and otherwise 0. Descriptive analysis was conducted to retain the appropriate variables. Some variables were dropped as their frequency distribution falls into greater than 95% or less than 5% of the sample. Then Principal Component Analysis has been used to make this index. STATA Version 15.0 (Stata Corporation, College Station, TX) has been used to estimate the index. We have used the first principal component to create the index by the 'predict var name' command because it explains the largest proportion of total variance. After getting the index value, we made a quartile distribution to summarize our data into five groups: 1 (Lowest), 2 (Second), 3 (Middle), 4 (Fourth), 5 (Highest).

RESULTS AND DISCUSSION

The study was conducted in 4 severely LSD affected districts, namely Dinajpur, Nilphamari, Rangpur and Sirajganj. We have considered mainly 2 types of farms like local breed farms and cross breed farms, and there were some both mixed farms. We can see from table 2 that most of the farmers (75%) are above 40 years old. Among those, in Nilphamari, 100% of the farmers are >40

years, and in Sirajganj, it is 97%. More young farmers are living in Dinajpur and Rangpur.

Table 3 shows that most of the farmers have more than a secondary level of education with 21% completing secondary or higher education. It is also found that farmers of Dinajpur and Rangpur are more educated than others.

Table 2: District-wise age category of the dairy farmers

Age of Respondents (category)	Number of dairy farmers according to districts				
	Dinajpur	Nilphamari	Rangpur	Sirajganj	Total
20 to 24	2	0	2	0	4 (1)
25 to 29	8	0	5	1	14 (4)
30 to 34	11	0	11	1	23 (6)
35 to 39	25	0	25	1	51 (14)
40 to above	56	88	46	97	277 (75)
Total	102	88	89	100	369 (100)

Source: Field survey, 2021

Table 3: District-wise education category of the dairy farmers

Educational qualification of farm owners	Number of dairy farmers according to districts				
	Dinajpur	Nilphamari	Rangpur	Sirajganj	Total
No institutional education	20	0	8	1	29 (8)
Incomplete primary education	9	0	12	11	32 (9)
Complete primary education	15	44	10	49	113 (31)
Incomplete secondary education	22	44	23	39	117 (32)
Complete secondary or Higher education	36	0	36	4	78 (21)
Total	102	88	89	100	369 (100)

Source: Field survey, 2021

Table 4: District-wise socio-economic category of the dairy farmers

5 quantiles of Wealth Index Score	Number of dairy farmers according to districts				
	Dinajpur	Nilphamari	Rangpur	Sirajganj	Total
Lowest (Poor)	27	0	23	15	74 (20)
Second (Lower middle class)	28	10	23	13	74 (20)
Middle (Middle class)	29	10	22	13	74 (20)
Fourth (Upper middle class)	18	29	17	29	88 (24)
Highest (Rich)	0	39	4	29	59 (16)
Total	102	88	89	100	369 100)

Source: Field survey, 2021

Household characteristics

In this study, we have calculated the socioeconomic status or wealth index for the farmers. The samples are nearly equally distributed among 5 categories from the lowest quantile to the highest quantile. But it is found that there are very less numbers of farmers in the highest quantile in Dinajpur and Rangpur where a comparatively higher number of rich farmers live in Nilphamari and Sirajganj.

Average herd size and affected number of cows of the dairy farmers

Table 5 represents the local and cross breed herd size of the area mentioned above. In Dinajpur district, 97 milking cows were affected by LSD

among 125 cows and all of them are local breed. About 25% of local breed milking cows were found affected in Nilphamari district. Only 14 local breed cows have been found in Sirajganj among 51 local breed cows. In Rangpur district, 23 local breed milking cows were found that were affected by LSD.

We have found a good number of cross breed cow in all four districts, of which 72%, 15%, 15% and 71% were affected in LSD among 613, 1158, 1504, 728 cows in Dinajpur, Nilphamari, Sirajganj and Rangpur respectively.

The average herd size of milking cows before the outbreak for the local breed was 2.06 of which the average affected number of cows was 1.52 and for cross breed the values were 4.46 and 1.94 (Figures 1 & 2). In case of local breed farms, 74%, 88%, 83%, 92%, 100%, 51% and 86% cows were affected in the case of milking cows, pregnant cows, heifer calves, bull calves, bullock, ox and fattening cattle respectively where the respective percentages are 43%, 59%, 45%, 62%, 80%, 45% and 78% in the case of cross-breed cows (Table 6).

Table 5: District-wise total number of cows and number of LSD affected cows

Types of breeds and cows		Dinajpur		Nilphamari		Sirajganj		Rangpur	
		Total number of cows	affected number of cows	Total number of cows	affected number of cows	Total number of cows	affected number of cows	Total number of cows	affected number of cows
Local	Milking cows	125	97	40	10	51	14	27	23
	Pregnant cows	44	33	8	0	11	0	13	11
	Heifer calves	71	66	33	0	44	0	17	17
	Bull calves	51	45	6	0	8	0	12	12
	Bullock	1	1	0	0	0	0	0	0
	Ox	2	1	31	3	40	5	1	0
	Fattening cattle	25	20	0	0	0	0	11	11
Total		319	263	118	13	154	19	81	74
Average herd size		3.1	2.6	1.3	0.1	1.5	0.2	0.9	0.8
Cross-bred	Milking cows	238	158	467	116	606	150	237	169
	Pregnant cows	97	61	122	11	159	14	125	85
	Heifer calves	126	107	315	15	408	19	173	114
	Bull calves	115	88	158	14	206	18	126	99
	Bullock	15	9	0	0	0	0	0	0
	Ox	0	0	96	17	125	21	3	3
	Fattening cattle	22	19	0	0	0	0	64	47
Total		613	442 (72%)	1158	173 (15%)	1504	222 (15%)	728	517 (71%)
Average herd size		6.0	4.3	13.2	2.0	15.0	2.2	8.2	5.8

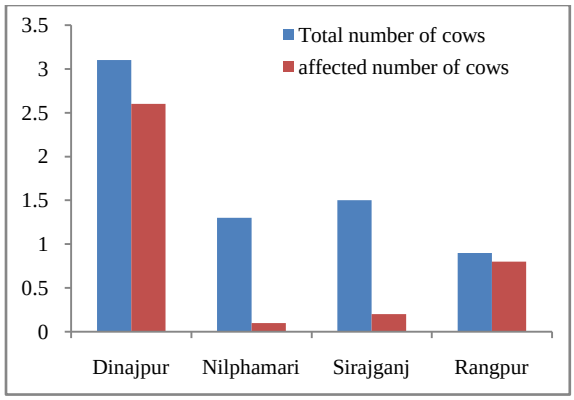

Figure 1: Average herd size and affected cows in case of local-breed cows

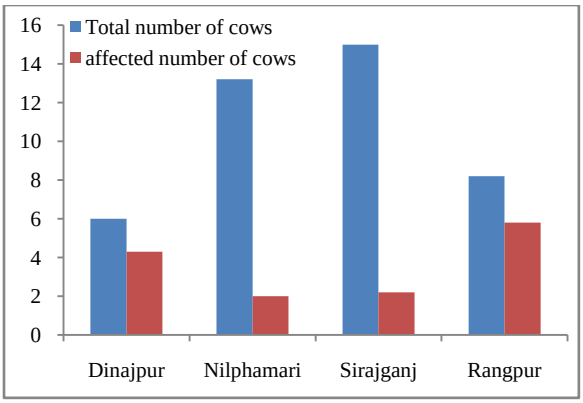

Figure 2: Average herd size and affected cows in case of cross-breed cows

Table 6: Average herd size and affected number of cows of the dairy farmers

Types of the livestock	Local breed			Cross breed		
	Average number of cows	Average affected number of cows	% of affected cows	The average number of cows	Average affected number of cows	% of affected cows
Milking cows	2.06	1.52	74	4.46	1.94	43
Pregnant cows	1.25	1.10	88	2.38	1.41	59
Heifer calves	1.56	1.30	83	3.34	1.49	45
Bull calves	1.20	1.10	92	2.39	1.47	62
Bullock	1.00	1.00	100	3.75	3.00	80
Ox	1.95	1.00	51	4.31	1.95	45
Fattening cattle	1.64	1.41	86	1.95	1.53	78

Table 7: District-wise average lactation period and milk production of dairy cows

District	Lactation period *(days)*	Daily milk production *(liter)*
Dinajpur	212	5.87
Nilphamari	257	5.16
Rangpur	237	7.89
Sirajganj	257	6.1

The highest lactation period has been found in both Nilphamari and Sirajganj districts and it is 257 days. Daily highest average milk production has been found in Rangpur district which is 7.89 liter. Sirajganj is on the second position following Dinajpur and Nilphamari in 3rd and 4th place. If we consider the breed types then it is seen that, cross breed farm has the highest lactation period and also produce the high milk production leaving mixed farm second and local farm in 3rd position in case of milk production. Lactation period is slightly higher in local breed farms than mixed farms.

Table 8: Breed-wise average lactation period and milk production of all dairy cows

Breed	Lactation period (days)	Daily milk production (liter)
Local	207.61	3.08
Cross	251.74	7.22
Mixed farm	205.58	6.12

Loss due to the attack of LSD

Direct cost infers to those costs that are incurred from all kind of production loss and changes in herd size or structure. In this study, the main production loss is calculated from daily milk loss and cost associated to regain the weight loss due to LSD. The change in hard size or structure is calculated from the incidence of death of farm

animals where all types of animals are included and their current market price is considered. On the other hand, indirect cost refers to the losses that are caused by LSD control and opportunity costs. In this study, we have considered treatment cost and cost of culling along with the opportunity cost such as owners' medication of anxiety and stress.

Considering breed types, number of only local breed was 44 and their average milk production was 21.69 liters after LSD. 258 cross breed cows have found used for milking purpose and their average milk production was 46.682 liters (Figure 3). We also found mixed types of breeds and the number of such kind of cows is 52 and their average milk production was 11.917. Some farms found that have no dairy cattle and have others type of cows. The price of milk ranges from 42 to 50 taka across all the four districts. Average milk loss have been estimated as 12% and 13% for local and cross bred farms respectively while the loss are 31%, 7%, 30% and 9% for Dinajpur, Nilphamari, Rangpur and Sirajganj respectively. Limon et al 2020 reported that Milk production dropped 65% when cows were clinically affected and 35% after they recovered from lumpy skin disease in Northeast Nigeria.

Table 9: Average milk production before and after LSD affected (Liter)

Breed type	Only local		Only cross		both		dairy cattle was not affected	
	No. of farms	Production (in litre)	No. of farms	Production (in litre)	No. of farms	Production (in litre)	No. of farms	Production (in litre)
Before LSD	44	24.77	258	53.96	53	18.21	12	48.67
After LSD	44	21.69	258	46.68	53	11.97	12	46
% of milk loss		12%		13%		34%		5%
Districts	Dinajpur		Nilphamari		Rangpur		Sirajganj	
Before LSD	102	18.86	88	71.39	89	26.85	100	69.12
After LSD	102	12.93	88	66.22	89	18.86	100	62.98
% of milk loss		31%		7%		30%		9%

Table 10: Breed-wise and district –wise costs of weight loss due to LSD

	Only local		Only cross		Both		Farms without affected dairy cattle	
Breed-wise	No. of farms	costs of weight loss	No. of farms	costs of weight loss	No. of farms	costs of weight loss	No. of farms	costs of weight loss
	25	1156	220	5446	28	6743	10	1448
District-wise	Dinajpur		Nilphamari		Rangpur		Sirajganj	
	49	5410	74	3557	62	12199	98	2239

Due to LSD infection, the farm animal might have weight loss which needs additional costs to be regained the previous weight; and for this, farmers usually provide supplementary food and medicine to the animal according to the prescription of a veterinary surgeon. Though in reality, most of the farmers at first take help from quack and they ask VS, when they are in danger. The cost of weight loss is calculated summing up all the expenses related to gain the previous weight such as cost of supplementary food items, cost of medicine, and cost of other items related to weight gaining process.

We can see that the cost of weight loss is lowest for those farms where only local breeds were

affected which is Taka 1156. The average cost of weight loss for cross breed is taka 5446 and for both cross breed and local breed is taka 6743. However, those farms where dairy cattle were not affected by LSD have comparatively lower cost of weight loss of taka 1448 on average. On the other hand, the per farm cost of weight loss is highest in Rangpur district (taka 12199) and lowest in Sirajganj district (taka 2239).

Treatment cost is the summation of all the cost items which are closely related to treatment of LSD such as, cost of drugs, fees of doctor, cost of transportation and other costs associated with treatment. Table 11 shows that the treatment cost is the lowest for those farms where milking cows is not affected by LSD (taka 2604). Those farms where the local breed was affected only have a treatment cost of an average taka 5243 and taka 7542 for cross breed. Those farms where both types of animals were affected have a significantly higher amount of treatment cost of taka 10151. Similarly, treatment cost is lower for Sirajganj district (Taka 2502) and highest for Dinajpur district (Taka 10771).

Cost of culling refers to those costs that are associated with the separation of LSD affected animal from healthy animals. When only cross breeds were affected in a farm, the average cost of culling was taka 1399 which is highest and when there is no affected milking cow in a farm, the cost of culling was lowest, taka 746. On the other hand, Rangpur district has the highest cost of culling of taka 1784 and the lowest in Dinajpur district, taka 895.

Table 11: Breed-wise and district-wise treatment cost due to LSD (per farm)

Breed type	Only local		Only cross		Both		farms without affected dairy cattle, but other types of animals affected	
	No. of animal	Mean	No. of animal	Mean	No. of animal	Mean	No. of animal	Mean
	44	5243	258	7542	53	10151	12	2604
District	Dinajpur		Nilphamari		Rangpur		Sirajganj	
	102	10771	74	3389	89	13379	98	2502

Table 12: Breed-wise and district-wise cost of culling due to LSD (per farm)

Breed type	Only local		Only cross		Both		farm without affected dairy cattle	
	No. of animal	Mean	No. of animal	Mean	No. of animal	Mean	No. of animal	Mean
	42	750	257	1399	51	1227	12	746
District	Dinajpur		Nilphamari		Rangpur		Sirajganj	
	97	895	74	1186	89	1784	98	1238

Table 13: Recovery Period from LSD (days)

Types of cows	Milking cow	Pregnant cow	Heifer calves	Bull calves	Fattening cow
Recovery Period (days)	7	10	11	11	9

Medical history of the animals

From our study we found that, heifer and bull calved take more time to get well from LSD (11 days) which is only 7 days for milking cow.

Only 8% farmers responded that sub-optimal breed was born in their farm due to LSD infection among which 70% were alive. Almost 95% farmers used the artificial insemination method for the reproduction purpose and 61% farmer took service from the veterinary surgeon over phone.

Table 14: Information relevant to herd and service

Questions	Yes answers (%)
Did any sub-optimal *(abnormal)* breed born in your herd?	30 (8)
If yes, does that alive?	21 (70)
Did you use artificial insemination?	345 (95)
Do you get service over phone?	222 (61)

The average cost of milk loss in Dinajpur, Nilphamari, Rangpur and Sirajganj (per farm) is taka 2892, 3664, 3816, 5364 respectively. Highest weight gain cost is found in Rangpur, 8498 taka and the lowest in Sirajganj, taka 2155. The lowest mortality cost is found in Nilphamari (Taka 0) and highest in Rangpur (taka 11798). The average direct cost (per farm) in Dinajpur, Nilphamari, Rangpur and Sirajganj is taka 10952, 7222, 24111 and 9637 respectively. Similarly, the total average indirect cost in Dinajpur, Nilphamari, Rangpur and Sirajganj is taka 116444, 4575, 15179 and 3693 respectively. The summation of total economic loss for Dinajpur, Nilphamari, Rangpur and Sirajganj is taka 22597, 11797, 39291, 13331 respectively.

Each cow direct cost is highest in Sirajganj (Taka 6389) and lowest in Dinajpur (Taka 1500). Per cow indirect cost is highest in Rangpur (Taka 2473) and lowest in Nilphamari (taka 1304). Highest per cow economic loss is found in Sirajganj (taka 8622) and lowest in Nilphamari (Taka 3185) (Figure 4).

We can see from the table 15 & 16 that the lowest average economic loss is found for the local breed and the highest is found for cross breed farms. However, the average economic loss for those farms where no dairy cattle were affected, have an even higher average economic loss of taka 25890.

We have done a sensitivity analysis for LSD considering 30 days as the reference period of recovery. From the analysis, we found that the total economic loss could vary between taka 11702 to taka 23403 with a timeframe of 20 to 40 days respectively (Figure 4).

Table 15: District-wise direct and indirect costs of LSD (if milk loss happens for 30 days)

Total Sample	102	88	89	100
District	Dinajpur	Nilphamari	Rangpur	Sirajganj
Total Average Direct cost	10952	7222	24111	9637
Milk loss (average)	2892	3664	3816	5364
Weight gain cost (average)	2599	3557	8498	2155
Total mortality loss (average)	5461	0	11798	2119
Total Average Indirect cost	11644	4575	15179	3693
Treatment cost (average)	10771	3389	13379	2471
Cost of culling (average)	851	1186	1784	1223
Owners' medication (average)	22	0	16	0
Total Economic loss	22597	11797	39291	13331
Direct cost per cow	1500	1881	3626	6389
Indirect cost per cow	1838	1304	2473	2233
Economic loss per cow	3339	3185	6099	8622

Table 16: Breed-wise average direct and indirect costs of LSD (if milk loss happens for 30 days)

Total Sample	44	260	53	12
Breed wise farms	Local-breed farms	Cross-breed farms	Mixed farms	Dairy cows were not affected
Total Average Direct cost	6880	14483	11251	-
Milk loss (average)	3950	4809	2537	0
Weight gain cost (average)	657	4608	3562	1207
Total mortality loss (average)	2273	5065	5151	-
Total Average Indirect cost	5959	8877	11350	3350
Treatment cost (average)	5243	7484	10151	2604
cost of culling (average)	716	1383	1180	746
Owners' medication (average)	0	10	19	0
Average Economic loss	12839	23360	22601	
Direct cost per cow	3340	3247	-	-
Indirect cost per cow	2893	1990	-	-
Economic loss per cow	6233	5238	-	-

Table 17: Sensitivity analysis of average direct and indirect costs of LSD (if milk loss happens for 20, 25, 30, 35 and 40 days)

Duration of LSD	20 days	25 days	30 days	35 days	40 days
Total Average Direct cost	8456	10570	12684	14798	16912
Milk loss (average)	4124	5154	6185	7216	8247
Weight gain cost (average)	2584	3230	3876	4522	5168
Total mortality loss (average)	1748	2186	2623	3060	3497
Total Average Indirect cost	3246	4057	4869	5680	6492
Treatment cost (average)	1923	2404	2885	3366	3847
cost of culling (average)	836	1045	1254	1463	1672
Owners' medication (average)	487	608	730	852	973
Total Economic loss	11702	14627	17553	20478	23403

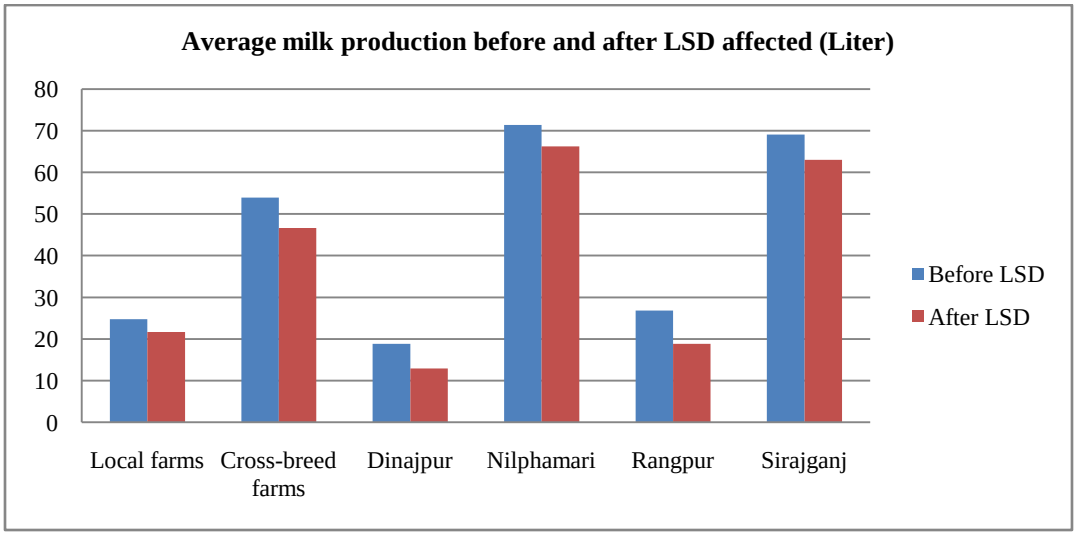

Figure 3: Average milk production before and after LSD affected

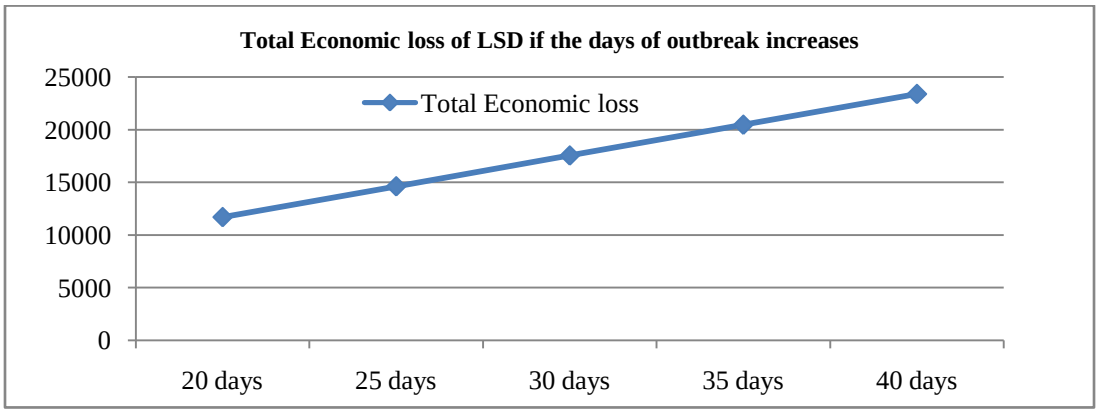

Figure 4: Total Economic loss of LSD if the day of outbreak increases from 20 days to 40 days

Table 18: District-wise average price of milk

District	Dinajpur	Nilphamari	Rangpur	Sirajganj
Price of milk *(taka/liter)*	50	42.07	46.38	44.67
Highest price of milk *(taka/liter)*	36	-	35	42
Lowest price of milk *(taka/liter)*	60	-	60	50

Table 19: District –wise costs of mortality loss due to LSD

Types of cows	Dinajpur		Nilphamari		Rangpur		Sirajganj	
	No. of animal	Mean	No. of animal	Mean	No. of animal	Mean	No. of animal	Mean
Calf	21	23190	0	0	15	27333	4	27250
Young animal	2	35000	0	0	5	66000	0	0
Adult	0	0	0	0	3	103333	1	230000

While calculating the farm's mortality loss, we have considered three types of cows; calf, young animal and adult cows. In Dinajpur, 20 calves had died with an average price of BDT 23190 and two young animals had died with an average price of BDT 35000. No farm animal has been found dead in the Nilphamari district. But in Rangpur, 15 calves, 5 young animals and 3 adult animals were found dead due to LSD attack and their average price was BDT 27333, BDT 66000 and BDT 103333 respectively. In Sirajganj, 4 claves died with an average price of BDT 27250. No young animal died here but one adult animal died and its price was BDT 23000. Biswas et al (2020) report recorded the mortality rate at 1.59% in Abhaynagar and 3.33% in Monirampur Upazila of Jashore District of Bangladesh during his study period. In Ethiopia, overall morbidity and mortality at the animal level were 21.2% and 4.5%, and at the herd level 82.3% and 24.3% were reported by Molla et al., (2017). In an interview-based study performed in Ethiopia, a case fatality of 9.3% and 21.9% was reported by Gari et al., (2011) in zebu and crossbred/Holstein Friesian cattle respectively. Sevik et al. (2016) Turkish researchers found a much higher case fatality in cattle in Turkey, reaching 54.8% in Holstein cattle. Mortality (which is the product of incidence and case fatality) usually does not exceed 1%–3% for LSD in most situations described by Tuppurainen (et al., 2012). In Kenya the mean farm-level losses from the reduction in milk yield and mortality were estimated at 4,725 KSH/97 USD and 3,103 KSH/31 USD for farms keeping indigenous breeds

whilst for farms keeping exotic breeds the equivalent losses were 26,886 KSH/266 USD and 43,557 KSH/431 USD, respectively were calculated by Kiplagat et al. (2020). Accurate estimation of case fatality was difficult to provide as in most of the developed countries, sick animals are culled and in developing countries, the exact pathological reason for natural animal death is not always provided (Klement et al., 2018).

Farmers' mental health: Other indirect costs which we did not measure

Farmers keep their livestock as their family members. Sometimes it is found that the owner's house is vulnerable but their farm house is luxurious. So, the owners of these farms are generally worried if their cows are infected with LSD or any other disease. The advice of a doctor is not always available. In this case, small and medium-sized farm cows are more affected than in the case of large farms. In large farms, if the cows are affected, the owners did not mention about too much tension. In this case, they have their own doctor hired. These doctors treated for the disease. Lower-middle-class farmers are very worried when their cows get sick. Sometimes the farmers get sick too. But they never go to the doctor for their own treatment. They think that when their cows get well, they will not have these worries anymore. Many farmers are involved in other activities besides raising cows. When one of their cows gets sick, they can't go to other jobs, spend time on the care of the cow. If anyone wants to understand the level of anxiety of the farmers, s/he has to go to them at the moment when the cow suffers from the disease. It is known from talking with such a victim that the disguised doctor prescribes medicine for only 400/500 taka and takes 8000 taka for a visit. When there is no physical development of the cow then the farmer contacts the veterinary hospital and from there the doctor sees high fever in the cow. In this situation, the farmer started screaming in a very compassionate voice. Seeing the cows are suffering, the farmer himself had been suffering. Besides the cattle business, the farmers also have some other works. They can't even go for those works if the cows are not recovered. They spend all day behind the cows. Therefore the earning from the secondary occupation also go wrong. Moreover, many of those lower class farmers may work as day laborers. In many cases, cows are treated with cow dung or use herbal treatment in rural areas. There is no scientific basis for this. In those areas where there is no doctor's facility, one farmer goes to another farmer for advice. In the beginning, the farmers were very upset because of the disease. When the prevalence of LSD increased in Dinajpur, there was no veterinary doctor available always. It is impossible to believe a farmer's mental condition when his cows are sick.

CONCLUSION

In conclusion, the results of this study alluded that the outbreak of LSD significantly increases the farmers' costs of livestock production. The study found direct and indirect costs for different regions. It could be mentioned here that livestock disease may make more breakthroughs in small farmers' lives than the large farmers. There are some other indirect costs like farmers' mental health could not be measured in this study. As the days of recovery increase, the costs of the disease increase. It is a common trend among small and medium farmers to take help from the quack, for which they suffer a lot. But this trend may remind us to increase the number of veterinarians as well as the number of trained para-vets in the dairy production regions.

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