Research article

Economic loss in poultry farms affected with highly pathogenic avian influenza A virus subtype H5N1 and low pathogenic avian influenza A virus subtype H9N2 in Chattogram, Bangladesh

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A R T I C L E I N F O	A B S T R A C T
	Depending on the degree of pathogenicity in chickens, avian influenza virus (AIV) are divided into highly pathogenic (HPAI) or low pathogenic AI (LPAI) viruses. Typically, high morbidity accompanied by high and rapidly escalating unexplained mortality is associated with a HPAI virus. On the other hand, LPAI viruses normally cause only a mild or no clinical disease, but under certain circumstances such as with concomitant infection(s) may also cause high mortality. However, published literature seems to be absent in Bangladesh on the economic loss caused by them at the affected farm level. This study was aimed at assessing the economic losses caused by highly pathogenic avian influenza A virus subtype H5N1 (HPAI H5N1) and low pathogenic avian influenza A virus subtype H9N2 (LPAI H9N2) on poultry farms. Cloacal and oropharyngeal samples from chickens supplied from 262 farms between October 2017 and April 2019 were investigated by real-time reverse transcription polymerase chain reaction (rRT-PCR). Of them birds on 16, 15 and 12 farms were diagnosed positive with HPAI H5N1, LPAI H9N2 and with the both, respectively. For each of the categories of infection five farms were randomly chosen and owners or farm representatives were interviewed with a pretested questionnaire to assess the economic losses attributed to them. The results revealed that the farm-level economic loss was variable depending on the number of birds housed on the day of clinical illness and the type of birds (i.e. broiler, layer and Sonali) reared. On the other hand, the average per-bird loss for broiler, layer and Sonali chickens due to HPAI H5N1 infection alone was around BDT 26, BDT 182 and BDT 82, respectively. No Sonali farm was diagnosed positive with LPAI H9N2 or HPAI H5N2 plus LPAI H9N2, and therefore, not included in the study. The average per-bird loss attributed to HPAI H5N1 plus LPAI H9N2 was BDT46 in layer and BDT 47 in broiler farm. On the other hand, the average per-bird loss caused by LPAI H9N2 alone was BDT62 in broiler, much higher than layer in which the estimate was BDT 46.5. To avoid economic loss attributed to HPAI H5N1 and LPAI H9N2 proper biosecurity should be practiced to keep the birds on farms free from the introduction of the viruses.

1. INTRODUCTION

The contribution of livestock and poultry to the national economy of Bangladesh is 2.5%; in which poultry sector contributes significantly (Hamid et al., 2017). This sector is a major protein supplier to the common people at the lowest price. However, occurrences of diseases, particularly those of infectious nature and high mortality potential have serious impact not only on the farmers' profitability but also in the disruption of supply of the products. Emerging zoonotic viruses of pandemic potential, such as highly pathogenic avian influenza virus subtype H5N1 (HPAI H5N1) can temporarily break the entire supply chain because of creating fear in the mind of consumers as was seen in 2007 due to the introduction of the virus for the first time in the country, resulting in stopping the operation of thousands of farms with enormous economic consequences across the country (Alamet al., 2010).

Avian influenza viruses are of two kinds, highly pathogenic and low pathogenic. A highly pathogenic avian influenza (HPAI) virus (HPAIV) can wipe out an entire flock, once affected. In contrast, a low pathogenic avian influenza (LPAI) virus (LPAIV) can cause variable mortality and reduce significant egg production (OIE, 2018). A LPAIV concomitantly infected with other pathogens, such as *Escherichia coli*, *Mycoplasma gallisepticum*, infectious bronchitis virus, Newcastle disease virus and other could also cause high mortality because of enhancing the cleaving of the cleavage site of the HA gene, allowing the virus to be attached to diverse host tissues apart from respiratory and gastrointestinal tract (OIE, 2008; Su et al., 2004; McMahon et al., 2005; Werth et al., 2010). HPAI H5N1 was, at first, reported in Bangladesh in 2007 (Biswas et al., 2008). At the same time, LPAI H9N2 was also reported (Biswas et al., 2008). There was a seasonal trend of its occurrences seen yearly from 2007 until 2012 when there was monetary compensation provision for farmers if their birds were detected for the virus and stamped out as eradication policy of the country. When such compensation policy ceased to operate, there were, in fact, very few outbreaks of HPAI H5N1 reported officially from the country to OIE. However, different studies, particularly, those carried out on birds in live bird markets and their environments suggested that the virus is persistently circulating in the country (Negovetich et al., 2011; Biswas et al., 2018; Kim et al., 2018). The preponderance of LPAI H9N2 was reported in most of the studies. To the authors' knowledge economic loss at the affected farm level of different types being caused due to occurrence of HPAI H5N1 or LPAI H9N2 or r both has perhaps never been studied in the country.

Poor knowledge of farm owners on strict maintenance of farm by applying ideal measures of biosecurity perhaps play role in the spread of HPAI H5N1 (Jahan et al; 2006). In such poor biosecurity setting, transmission of the virus from poultry to humans is a reality, and mutations of the viruses in different hosts are hypothesized. Most studies, therefore, conducted elsewhere in the world were concentrated on virus epidemiology, evolution and molecular marker analyses to assess the viruses in the angle of public health impacts. Seemingly, proper attention has not been paid to the economic losses caused by the viruses at the affected farm level although data from FAO of the United Nations revealed that HPAI H5N1 resulted in loss of USD 20 billion globally by 2006(Harris, 2006). Valid data on the economic losses caused by HPAI H5N1 or LPAI H9N2 or their mixed involvement are seemingly absent although there was an earlier study conducted in Bangladesh indicating the country-wide probable economic loss due to introduction of HPAI H5N1 (Alam et al., 2010). Nothing is known on how much a farmer would loss if a farm is affected with HPAI H5N1 or LPAI H9N2. Here, we describe the probable economic loss at the farm level as well as the affected bird level when chickens of different types on farms are infected naturally with HPAI H5N1 or LPAI H9N2 or with the both simultaneously.

2. MATERIALS AND METHODS

Selection of farms affected with HPAI H5N1, LPAI H9N2 and both the subtypes

Samples from 262 farms were investigated during the period October 2017 – April 2019. Dead or clinically sick birds were submitted from these farms to two registered veterinarians specialized in poultry diseases and a disease

diagnostic laboratory named Animal Disease Diagnostic Laboratory (ADDL) at the Poultry Research and Training Centre (PRTC) of the Chattogram Veterinary and Animal Sciences University (CVASU). Pooled (2 to 5 in a pool depending on the numbers of birds supplied from farms) oropharyngeal or tracheal swab samples collected from the birds of the farms were investigated for the presence of the matrix gene (M) of AIV followed by H5 and H9 in the M gene positive samples by real-time reverse transcription polymerase chain reaction (rRT-PCR) using the CSIRO (The Commonwealth Scientific and Industrial Research Organization) (www.csiro.au) Australian Animal Health Laboratory protocols. The laboratory investigations on the biological samples identified 16 farms with HPAI H5N1, 15 with LPAI H9N2 and 12 with the both. These positively identified farms with virus subtypes mentioned were used as the sample frames and 15 of the farms taking 5 each for HPAI H5N1 positive, LPAI H9N2 positive and both subtypes positive category were selected from the sample frames for this study.

Questionnaire for data collection

A prototype questionnaire to collect data associated with economic loss due to occurrence of HPAI H5N1, LPAI H9N2 and both subtypes was designed (The questionnaire is available on request). The questionnaire includes 28 questions and were aimed to collect data on the economic losses attributed to bird mortality, reduction in egg production (in case of layer birds), extra veterinary services, extra-cost for medicine, extra-disinfectants, extra-isolator cost required for segregating apparently healthy from clinically sick birds, changing of extra farm utensils, employment of extra man-power to dispose of dead birds and any other costs. The farm owner of a selected farm or his/her representative/farm attendant who submitted the clinically sick or dead birds was contacted over cell phone, and an interview with the owner/representative after the end of the disease occurrence was taken either physically or over phone according to the options and suitable time provided by the owner. If the sample submitter was a representative/farm attendant of the farm owner, the owner was sometimes additionally communicated over mobile phone to have supportive information to complete the questionnaire.

Statistical analysis

All data collected from the questionnaire-based interviews were entered into a spread-sheet program (Microsoft Excel 2010) and the data were separated by subtype of the virus involved in the disease occurrence and the kind of farm type (i.e. broiler, layer or Sonali [A cross-bred of Fayoumi (Female) and Rhode Island Red (Male)]) affected. The data with the spread-sheet were transferred to STATA statistical package (Stata Corporation, College Station, Texas 77845 USA) for data analysis. The total loss of a farm affected with a virus subtype was calculated by summing up the losses associated the individual areas as mentioned in the above section. The mean (with standard deviation, wherever applicable) loss of a farm category for a specific subtype of virus involved was at first calculated. The per-bird loss per farm type affected with a particular virus subtype was then calculated from the total loss divided by the number of birds housed on day of the clinical onset of the disease.

3. RESULTS

The spatial distributions of farms diagnosed positive with HPAI H5N1, LPAI H9N2 and both the subtypes are shown in Figure 1. Of the five HPAI H5N1 positive farms selected for this study, one belonged to broiler, three to layer and one to Sonali type. The total number of birds when the broiler farm was affected with the virus was 1800 and the age of the birds was 2.6 wk. The economic loss per farm , as estimated was BDT 27550 due to mortality, BDT 300 due to veterinary service, BDT14000 due to extra medicinal cost, BDT 2000 due to extra cost for disinfectants, BDT 600 due to isolation cost, BDT 1000 due to extra man-power required and BDT 1000 due to other purposes (Table 1, Part a). In total, the economic loss was BDT 46450, meaning that the average per-bird loss was BDT 26. Of the three layer farms, the total number of birds housed on the day of the onset of clinical illness was 1000, 2000 and 1800 and the age of the birds was 67wk, 64 wk and 74 wk, respectively. The total loss associated with the disease outbreak was BDT 186838, BDT394860 and BDT286590 for the first, second and the third layer farm with an estimated loss of BDT 187, BDT 198 and BDT 160 per bird per farm, respectively, suggesting that the per-bird loss was BDT 181.7. The respondents were reluctant

to disclose what they did with the apparently healthy birds while seeing a high mortality in clinically sick birds. The possibility of selling them could not be ruled out. The per-bird loss in Sonali farm was BDT 82.

No Sonali farm was diagnosed positive with HPAI H5N1 plus LPAI H9N2, and therefore, only broiler and layer farms diagnosed positive with both the virus subtypes were included in the study. Of them, four belonged to broiler and only one to layer. The number of birds on the layer farm was diagnosed with the virus subtypes was 2855 and the age of the birds was 42 wk. The loss, if fragmented by different areas, were BDT 44460, BDT 11036, BDT 500, BDT 70000 and BDT 5000, respectively, for mortality, reduced egg production, veterinary service, medicinal cost and cost for buying of extra disinfectants (Table 1, Part b). The total loss was BDT 130996, showing that the per-bird loss wasBDT46. The number of broiler birds housed on the day of the beginning of clinical illness was 790 on the 1st, 500 on the 2nd, 1435 on the 3rd and 2000 on the 4thbroiler farm, and the age of the birds on the farm was 2.5 wk, 2 wk, 2 wk and 2.1 wk, respectively. The total loss owing to the outbreak caused by both the subtypes was BDT 22020 for Farm 1, BDT 31390 for Farm 2, BDT 51600 for Farm 3 and BDT 121175 for Farm 4, indicating that the per-bird loss was BDT 47.

No Sonali farm was diagnosed with LPAI H9N2 either. Of the five farms included for the virus subtype three belonged to broiler and two to layer. On layer farm 1 and 2 (Two) 1500 and 995 birds of 40 and 34.7 wk of age were housed, respectively. The total loss covering mortality and other areas was BDT 67833 for farm 1 and Tk 47485 for farm 2, showing that the per-bird loss was BDT 46.5 (Table 1, Part c). The total number of birds housed on broiler farm 1, 2 and 3 on the day of the appearance of clinical symptoms was 670, 1450 and 1700, and the age of the birds was 2.6 wk, 3.1 wk and 3.3 wk, respectively. The total loss incurred due to the outbreak of LPAI H9N2 was BDT50425 for farm 1, BDT 110300 for Farm 2 and BDT 55400 for farm 3, indicating that the per-bird loss was BDT62.

The mean (and range wherever applicable) economic loss per farm of different bird types and the mean (and range wherever applicable) economic loss per-bird of different bird types due

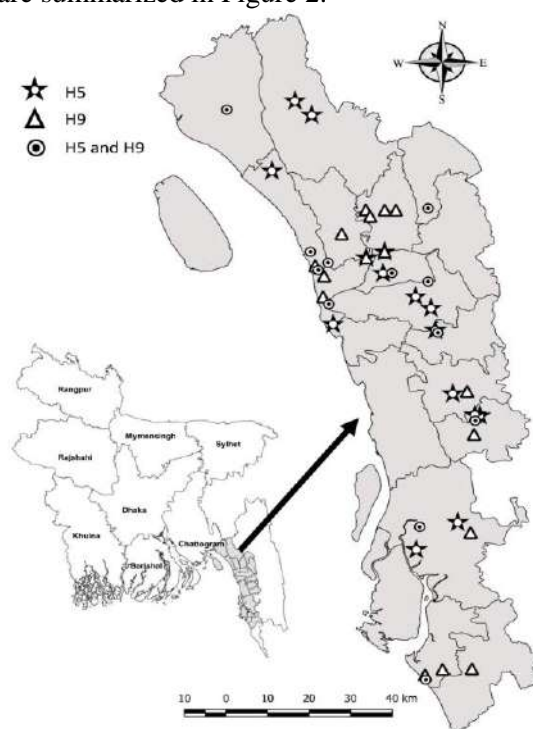to the occurrences of HPAI H5N1, LPAI H9N2 are summarized in Figure 2.

Figure 1. Geographical distribution of farms diagnosed positive with HPAI H5N1, LPAI H9N2 and both the subtypes from which five for each of the category were included in this study.

4. DISCUSSION

Economic losses due to occurrence of HPAI H5N1 alone, LPAI H9N2 alone and their both involvement in chicken farms were investigated at the farm level and at the bird level. To the authors' knowledge, this seems to be the first ever study conducted in Bangladesh on economic losses attributed to the common AIV subtypes at the farm level and at the bird-level. In fact, economic analysis on the impact of AIV on poultry farms is scanty in Bangladesh. One study conducted before by Alam et al (2010) revealed that the overall poultry industry in the country suffered a huge economic loss in 2007 and in 2008 due to an avian influenza incursion and the loss was supposed to be around 38580 million in Taka. During that early phase of HPAI outbreaks broiler prices dropped by about 28 percent while egg prices fell by 26.5 percent. More than a third of consumers abstained from eating broiler meat and eggs. As a consequence of this collapse of the market, many farm owners were forced to abandon raising poultry because of capital loss (Alam et al., 2010).

Table 1. Economic analysis of the poultry farms affected:

(a) - with highly pathogenic avian influenza A virus subtype H5N1 (HPAI H5N1)

Farm type	Farm no.	Age (wk)	No. affected	No. died	Market price of a bird	Loss due to mortality	Drop in egg production	Loss due to less egg produced	Vet – service cost	Medicinal cost	Disinfectant cost	Isolation cost	Farm utility change cost	Extra man-power cost	Other	Total loss	Loss/ bird
Broiler	1	2.6	1800	200	145	27550	NA	NA	300	14000	2000	600	NA	1000	1000	46450	26
Layer	1	67	1000	250	158	75050	Yes	66938	500	37500	3500	1350	2000	-	-	186838	187
	2	64	2000	300	190	131100	Yes	242760	500	18000	1000	-	-	-	1500	394860	198
	3	74	1800	900	120	172800	Yes	7290	1500	100000	5000	NA	NA	NA	NA	286590	160
Sonali	1	3	1500	1050	165	99619	-	-	1000	17500	700	2300	-	1000	-	122119	82

(b) - with HPAI H5N1 plus low pathogenic avian influenza A virus subtype H9N2 (LPAI H9N2)

Farm type	Farm no.	Age (wk)	No. affected	No. died	Market price of a bird	Loss due to mortality	Drop in egg production	Loss due to less egg produced	Vet – service cost	Medicinal cost	Disinfectant cost	Isolation cost	Farm utility change cost	Extra man-power cost	Other	Total cost	Loss/ bird
Broiler	1	2.5	790	120	120	15120	-	-	300	4300	300	1200	-	800	-	22020	28
	2	2	500	50	120	27000	-	-	200	2800	90	1300	-	-	-	31390	63
	3	2	1435	200	120	36000	-	-	600	15000	-	-	-	-	-	51600	36
	4	2.1	2000	700	105	62475	-	-	700	57000	1000	-	-	-	-	121175	61
Layer	1	42	2855	130	190	44460	Yes	11036	500	70000	5000	-	-	-	-	130996	46

(c)- with LPAI H9N2

| Farm type	Farm no.	Age (wk)	No. affected	No. died	Market price of a bird	Loss due to mortality	Drop in egg production	Loss due to less egg produced	Vet – service cost	Medicinal cost	Disinfectant cost	Isolation cost	Farm utility change cost	Extra man-power cost	Other	Total cost	Loss/ bird
Broiler	1	2.6	670	350	105	40425	-	-	1000	5500	3500	-	-	-	-	50425	76
	2	3.1	1450	1000	120	84000	-	-	300	25000	1000	-	-	-	-	110300	77
	3	3.3	1700	250	117	35100	-	-	1500	18000	800	-	-	-	-	55400	33
Layer	1	40	1500	80	180	21600	Yes	1533	1700	36000	500	6500	-	-	-	67833	45.2
	2	34.7	995	23	160	6072	Yes	21713	500	18000	1200					47485	47.7
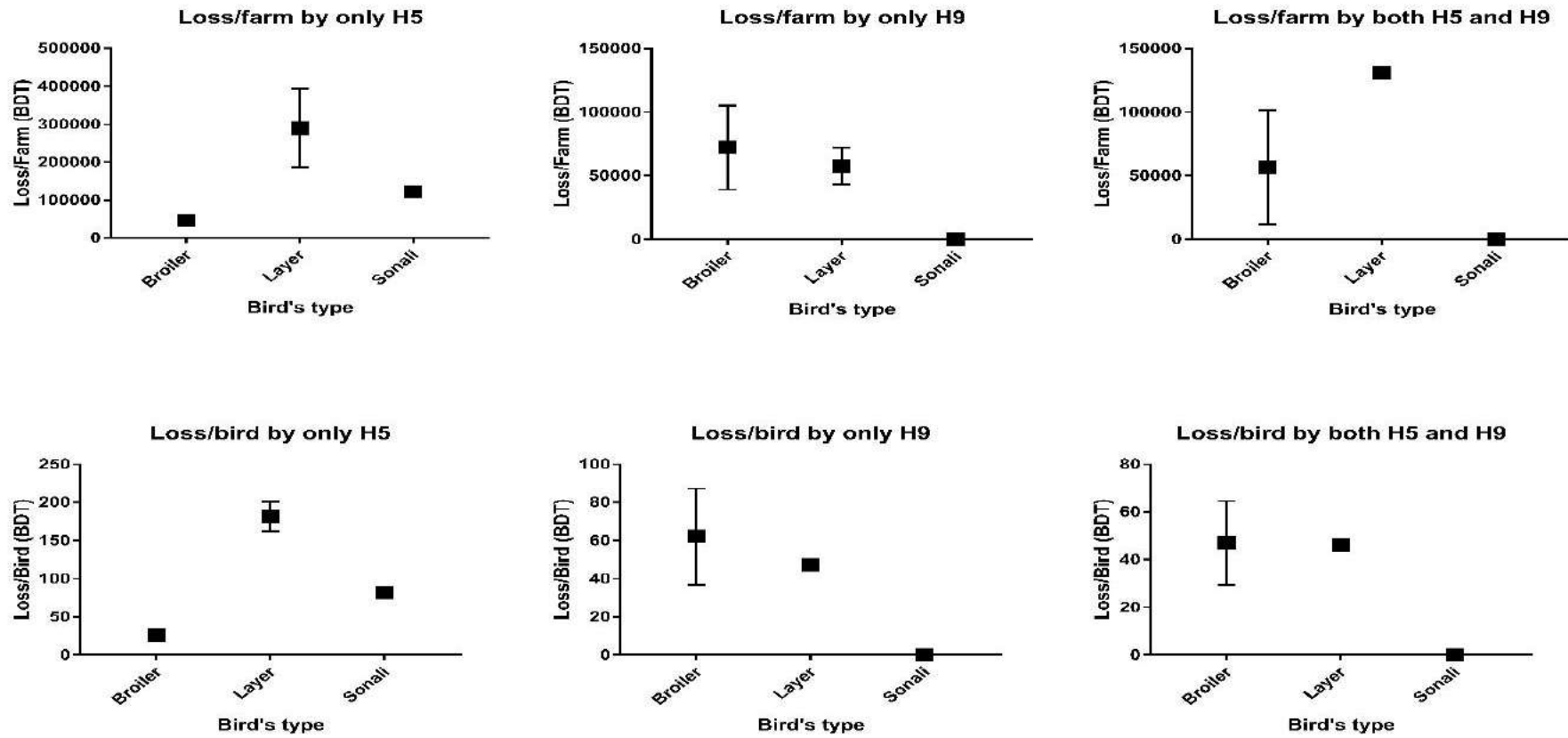
Figure 2. Economic loss per farm and per-bird due to HPAI H5N1, LPAI H9N2 and both the subtypes in broiler, layer and Sonali farm – the top three panels are for showing the loss at the farm level and the bottom three are for per-bird level

The farms investigated in this study are of small- and medium-sized and the results revealed that economic losses attributed to the occurrence of HPAI H5N1 or LPAI H9N2 alone or their mixed involvement varied, which seemed to be correlated to the variable numbers of birds housed and affected with a particular virus subtype. So, based on the results obtained from the study on the loss at the farm level, it was difficult to generalize the economic loss for broiler, layer or Sonali farms when there is huge variation in the numbers of birds reared on these types of farms. Considering this, the loss was also estimated at the bird-level which could provide a tentative indication to calculate the extent of loss a farm could incur due to outbreak of a particular virus subtype.

The results indicated that the per-bird loss due to HPAI H5N1 outbreak was around BDT182 for layer, BDT82 for Sonali and BDT26 for broiler birds. The results of this study could not be compared with any other findings of similar studies because an extensive literature search revealed absence of such published articles in the past in the country. Because the layer birds were in advanced laying stage, the loss could be higher. Additionally, the farmers perhaps tried all therapeutic efforts to save the birds which needed a higher cost for medicine. On the other hand, when the owners noticed the appearance of clinical illness in the broiler birds, they could start selling the birds at the premature age, with an aim to keep the loss reduced. The same could happen for Sonali birds. However, it was surprising to see that almost a similar per-bird loss, BDT 46 and BDT 47, respectively, was noticed in layer and broiler farms affected with both HPAI H5N1 and LPAI H9N2 viruses. This is difficult to explain, but unethical salvage selling could play some roles that could have confounding effects in finding a lower level of loss compared with the loss caused by HPAI H5N1 alone. The per-bird loss attributed to LPAI H9N2 alone in broiler was BDT62, much higher than layer, which was BDT 46. The explanation was that, perhaps, the affected birds were concomitantly affected with other bacterial pathogens and when these pathogens were treated successfully by using antimicrobials the mortality seen was checked. Immune status of broiler birds could be lower compared with older layer birds which perhaps made younger broiler birds suffer more severely than layer, causing a higher mortality. These birds could also require prolonged and intensive treatment for which additional medicinal cost could be involved. While accepting so, there could be many other external management and intrinsic bird-level factors contributing to broiler birds to become more prone to develop a severe clinical disease with LPAI H9N2.

The respondents included in the study were reluctant to disclose the fate of the apparently healthy birds after the onset of the clinical illness - whether or not they also developed clinical illness and succumbed to the virus. Or, they sold the birds as part of salvage selling to reduce the extent of loss. While this kind of selling is ethically unacceptable and prohibited by existing law in the country (DLS, 2008), such practice could not be entirely ruled out. If such selling was in practice, which could not be known, the economic loss per bird could be lower but at the same time it helped wider dissemination of the viruses. To stop it, a proper surveillance to find out hidden infections of the viruses through proactive reporting from farmers with the provision of providing monetary compensation for the affected farms is required.

One might have doubt on the authenticity of the data provided by the interviewees in response to the questions particularly on isolation cost, farm utility cost and extra man-power costs. Some degree of recall bias in providing exact information on them and on several other questions could also not be controlled by the ways of interviews taken with different kinds of interviewees. However, such kinds of probable limitations suspected to have impact on the authenticity of the results obtained can be verified by a more controlled way of data collection and by involving a more homogeneous group of affected farmers in the future.

Another limitation of this study was the sample size of the farms included in the study. But this should not undermine the importance of the study knowing the fact that no information before this present study was available in the country on the per-bird economic loss due to the outbreaks of HPAI H5N1, LPAI H9N2 and the involvement of the both on broiler, layer and Sonali farms. This study generated some valuable baseline information on the possible economic loss that could be caused by the outbreaks of the viruses. A more extensive study employing greater numbers of farms belonging

to different production types across the country is recommended to verify the authenticity of the results obtained from this study.

5. CONCLUSIONS

If affected with HPAI H5N1, the per-bird economic loss in layer, Sonali and broiler bird would be BDT 182, BDT 82 and BDT26, respectively. And, when infected with LPAI H9N2, the per-bird economic loss for broiler is BDT62, substantially higher compared with per-bird loss in layer which appears to be around BDT 46. A more comprehensive study employing a greater number of farms distributed across the country is recommended to have a better picture on the economic losses caused by HPAI H5N1 and LPAI H9N2 at the farm-level taking information from this study as a baseline because such kind of study has never been done before in the country.

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REFERNCES

Alam, J., Giasuddin, M., Samad, M.A. and Taimur, M.J.F.A. 2010. Recent evidence of Avian Influenza in Bangladesh: a review. World's Poultry Science Journal 66:455-464.

Biswas, P.K., Christensen, J.P., Ahmed, S.S., Barua, H., Das, A., Rahman, M.H., Giasuddin, M., Hannan, A.S., Habib, M.A., Ahad, A. and Rahman, A.S. 2008. Avian influenza outbreaks in chickens, Bangladesh. Emerging Infectious Diseases, 14:1909.

Biswas, P.K., Giasuddin, M., Chowdhury, P., Barua, H., Debnath, N.C. and Yamage, M. 2018. Incidence of contamination of live bird markets in Bangladesh with influenza A virus and subtypes H5, H7 and H9. Transboundary and Emerging Diseases, 65:687-695.

DLS (Department of Livestock Services). Animal Disease Rules, 2005 (in Bangla) (http://old.dls.gov.bd/files/Animal%20Disease %20Rule-%202008.pdf), Dhaka 2008. Accessed on 15 December 2020.

Hamid, M.A., Rahman, M.A., Ahmed, S. and Hossain, K.M. 2017. Status of poultry industry in Bangladesh and the role of private sector for its development. Asian Journal of Poultry Science, 11:1-13.

Harris, P. 2006. The FAO approach: Avian influenza: An animal health issue. Retrieved from the Food and Agriculture Organization (FAO), Agriculture Department Animal Production and Health Division website: http://www. fao. org/avianflu/en/issue.html. Accessed 25 October 2020.

Jahan, T. and Sultana, M.S. 2006. The Socio-Economic Status of Poultry Industry after the Outbreak of Avian Influenza in Bangladesh. Journal of Teacher Education 4:161-170.

Kim, Y., Biswas, P.K., Giasuddin, M., Hasan, M., Mahmud, R., Chang, Y.M., Essen, S., Samad, M.A., Lewis, N.S., Brown, I.H. and Moyen, N. 2018. Prevalence of avian influenza A (H5) and A (H9) viruses in live bird markets, Bangladesh. Emerging Infectious Diseases, 24:2309.

McMahon, S., Grondin, F., McDonald, P.P., Richard, D.E. and Dubois, C.M. 2005. Hypoxia-enhanced Expression of the ProproteinConvertaseFurinis Mediated by Hypoxia-inducible Factor-1 Impact on the Bioactivation of Proproteins. Journal of Biological Chemistry, 280:6561-6569.

Negovetich, N.J., Feeroz, M.M., Jones-Engel, L., Walker, D., Alam, S.R., Hasan, K., Seiler, P., Ferguson, A., Friedman, K., Barman, S. and Franks, J. 2011. Live bird markets of Bangladesh: H9N2 viruses and the near absence of highly pathogenic H5N1 influenza. PLoS One, 6:e19311.

OIE (World Organization for Animal Health). Manual of diagnostic tests and vaccines for terrestrial animals: Chapter 3.3.4 – Avian influenza (infection with avian influenza viruses) (https://www.oie.int/fileadmin/Home/eng/Healt h_standards/tahm/3.03.04_AI), Vienna, 2018.Accessed on 15December 2020.

Su, A.I., Wiltshire, T., Batalov, S., Lapp, H., Ching, K.A., Block, D., Zhang, J., Soden, R., Hayakawa, M., Kreiman, G. and Cooke, M.P., 2004. A gene atlas of the mouse and human protein-encoding transcriptomes. Proceedings of the National Academy of Sciences, 101, 6062-6067.

Werth, N., Beerlage, C., Rosenberger, C., Yazdi, A.S., Edelmann, M., Amr, A., Bernhardt, W., Von Eiff, C., Becker, K., Schäfer, A. and Peschel, A., 2010. Activation of hypoxia inducible factor 1 is a general phenomenon in infections with human pathogens. PLoS One, 5, e11576.