

KNOWLEDGE AND ATTITUDE TOWARDS ANTHRAX AT THE ANTHRAX BELT SIRAJGONJ DISTRICT IN BANGLADESH

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ABSTRACT

Background: Anthrax is one of the most important endemic zoonotic diseases due to its negative impact on the smallholder farmers associated with mortality in livestock and disease in humans in Bangladesh.

Objective: The main objective of this investigation was to assess the extent of knowledge, awareness, attitude and practices addressing anthrax in animals and humans in the communities of Bangladesh

Materials and Methods: A descriptive cross-sectional survey was conducted in the ‘anthrax belt’ Sirajgonj district where several anthrax outbreaks have been reported in both the livestock and humans. A total of 26 household were selected randomly for sampling from each of four villages during the period from August to December 2013. A total of 104 adult respondents participated in the questionnaire survey and the data were calculated by using the formula $4pq/d^2$ and Chi-square test using software.

Results: Result shows that 55.8% of the community respondents had knowledge of anthrax, while 44.2% of them did not. Analysis of anthrax cases record obtained from respondents showed 49.8% animals, 44.0% humans and 6.2% birds affected with this disease. Only 18.3 to 28.2% respondents knew the clinical signs cutaneous, gastro-intestinal and pulmonary forms, whereas 13.3 to 25.5% respondents knew more than one transmission routes in animals and humans. A certain percentage (2.9 to 16.8% & 8.9 to 20.9%) of community people obtained information on the outbreaks of anthrax in animals and humans from communication media, NGO workers and community health workers.

Conclusions: The knowledge on anthrax of the participants was low with no consistent understanding of the disease. The educated family members in farming practices could improve the awareness and knowledge towards zoonotic diseases including anthrax. These findings could be useful for the decision makers to build technical capacity of veterinary medical services and to foster a ‘One Health’ approach especially a continued infection prevention and control training program for animal owners and local residents with close surveillance and reporting, burying or cremation of dead animal carcasses and decontamination and disinfection procedures as well as immunization of animals against anthrax to prevent the infection in endemic areas.

Keywords: Anthrax, Bangladesh, Questionnaire survey, Knowledge, Attitude, Anthrax belt district

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INTRODUCTION

The word 'anthrax' is derived from the Greek word for coal, 'anthrakis' because of its ability to cause black, coal-like cutaneous eschars.¹ Anthrax is one of the most important bacterial diseases caused sudden death in ruminants of high economic and public health importance. Globally, 20,000 to 100,000 incidents of human anthrax cases have been estimated annually² with a significant number of cases in Chand, Ethiopia, Zambia, Zimbabwe and India³ and recently a number of anthrax outbreaks have been reported in both animals and humans from Bangladesh.⁴ The animal anthrax is locally known as 'Torka' (Bangla language) due to sudden death of affected animals, caused by *Bacillus anthracis*, gram positive, rod-shaped, non-motile bacterium. This organism exclusively remain in the vegetative form inside the host within low oxygen environment and it forms spore outside the host in the presence of free oxygen in cultures, in soil and in tissues and exudates of dead animals. Spores are highly resistant to biological extremes of heat, cold, pH, desiccation, chemicals, irradiation and other such adverse conditions. The rate and degree of sporulation are influenced by the environmental conditions such as temperature, humidity and available water in the micro-environment, pH, oxygen availability, sun light and presence of cat-ions.^{3,5} Anthrax is primarily disease of herbivores and secondarily humans and accordingly, the outbreak of anthrax in human is usually preceded by animal outbreaks. Grazing of animals in the anthrax spore contaminated pasture or feeding animals with contaminated grasses and even water contaminated with anthrax spores are the most common sources of infection. All the reported anthrax affected human cases in Bangladesh with a history of contact with the animal carcasses, handling and processing with infected meat.⁶⁻⁹ Sick animals are usually slaughtered to minimize their economic loss and some people purchase the relatively cheap meat from these animals. During outbreak periods, the supplies of hides to the 60 tanneries fall sharply, affecting tannery owners and the 70,000 tannery workers in Bangladesh.⁸ Due to lack of knowledge about risks from an incorrect removal of infected carcasses, the disease is not properly monitored and because of the socio-economic conditions, the situation is under-reported and under-diagnosed.¹⁰ Depending on route of exposure, cutaneous, gastro-intestinal and inhalational forms of the disease occur in humans. Anthrax organism can penetrate into the host through micro-abrasions or cuts (developing a cutaneous form), via inhalation of the spores (pulmonary form) and through the consumption of infected meat (intestinal form). Anthrax outbreaks in animals and humans have been associated with ecological, demographic and socio-cultural factors^{11,12} including unique characteristics of the bacterium, environmentally related features, animal densities and human activities.^{5,13,14} Outbreaks of anthrax have been reported in humans and/or livestock in 15 districts in Bangladesh. Pabna, Sirajgonj and Tangail districts have been reported as apparently forming a spatial cluster that could be termed 'anthrax hot spot' in Bangladesh.^{5,15,16} The outbreak was firstly recognized in the Sirajgonj district.¹⁷ There were 104 animal cases of anthrax and 607 associated human cases in Sirajgonj district in December 2010.¹³ Human behavior¹⁸ and socio-demographic factors¹⁹ could affect the knowledge, attitude and practices (KAP) of a given community towards anthrax. Demonstrating evidence of KAP regarding anthrax can be used to determine the prevention strategy for the disease.¹⁴ Considering these

fact, this investigation aimed at assessing the knowledge and attitude towards anthrax in the district of Sirajgonj.

MATERIALS AND METHODS

The experiment was conducted among people living in 4 selected villages (Barahar, Durganagar, Hatikumrul, Mohanpur) Ullahparah upazila at Sirajgonj district of Bangladesh. Interview was taken to collect data from the respondents during August 2013 to December 2013. The sample size was 104, calculated using the formula $4 pq/d2$. A pre structured questionnaire was used to assess knowledge and attitude related to anthrax among the respondents. Then the data was collected, analyzed and entered into Excel. The frequency of socio-demographic variables, knowledge and attitude among respondents were expressed in proportions.

RESULTS

This investigation on the knowledge, attitude and practices on anthrax in humans and animals was conducted with pre-prepared questionnaire with interview with an overall of 104 respondents in which included farmers, community members and professionals (Table 1). Of the 104 respondents, 45.2% people were illiterate and 54.8% people had primary to graduate level of education (Table 1). Majority of the respondents were farmers (51.91) and 48.1% others which included community members and professionals (Table 1). Overall 55.8%

Table 1. Distribution of respondent population on anthrax questionnaire with interview in the anthrax belt Sirajgonj district in Bangladesh								
S/N	Sources and/or criterion	Respondents No. (%)	S/N	Sources and/or criterion	Respondents No. (%)	S/N	Sources and/or criterion	Respondents No. (%)
1. Education			5. Transmission			d.	Imam (mosque)	62 (12.0)
a.	Illiterate	47 (45.2)	a.	Eating	100 (25.5)	e.	Neighbor	66 (12.8)
b.	Up to graduate	57 (54.8)	b.	Inhalation	66 (16.8)	f.	Shopkeeper	58 (11.2)
	Total	104 (100)	c.	Vector	52 (13.3)	g.	Political leader	38 (07.4)
2. Occupation			d.	Handling	99 (25.3)	h.	Family members	15 (02.9)
a.	Farmers	54 (51.9)	e.	Contact	75 (19.1)	i.	Physician (Dhaka)	61 (11.8)
b.	Others	50 (48.1)		Total	392 (100)		Total	517 (100)
	Total	104 (100)	6. Symptoms			8. Others		
a.	Satisfactory	58 (55.8)	a.	Pulmonary	59 (18.3)	a.	CHW	67 (16.1)
b.	Unsatisfactory	46 (44.2)	b.	Gastro-intestinal	78 (24.1)	b.	Private clinic	66 (15.8)
	Total	104 (100)	c.	Cutaneous	91 (28.2)	c.	Poster	53 (12.7)
4. Affected			d.	Fever	95 (29.4)	d.	Television (TV)	87 (20.9)
a.	Human	92 (44.00)		Total	323 (100)	e.	Daily newspaper	63 (15.1)
b.	Animals	104 (49.8)	7. Professionals			f.	Bangladesh Radio	37 (08.9)
c.	Birds	13 (06.2)	a.	NGO	56 (10.8)	g.	Hospital records	44 (10.6)
	Total	209 (100)	b.	Health workers	74 (14.3)		Total	417 (100)
			c.	Physician	87 (16.8)			

CHW = Community health workers

Others = Community members and professionals

respondents had satisfactory knowledge of the disease of animals and its zoonotic importance, whereas 44.2% had unsatisfactory knowledge on the disease (Table 1). A total of 209 anthrax cases were recorded based on respondent information, of which 44.0% in humans, 49.8% in animals and 6.2% in poultry birds (Table 1).

Table 1 also shows that 25.5% respondent had knowledge about transmission of the disease by eating infected meat that caused gastro-intestinal form of anthrax in 24.1% cases, and handling caused 25.3% infection with 28.2% cutaneous form of anthrax.

Highest information on the anthrax was obtained from physicians working in local (16.8%) and in the capital Dhaka hospitals (11.8%) as well as from local health workers (14.3%). In addition, non-government organization (NGO; 10.8%), mosque imam (12.0%), shopkeeper (11.2%) had more knowledge on the disease than the political leaders (7.4%) associated with public activities (Table 1). Mass media especially television, radio, daily newspaper and others are being broadcasting news of anthrax outbreak in animals and humans from different districts in Bangladesh but only 20.9% people utilized TV, 15.1% newspaper and only 8.9% radio (Table 1).

The prevalence of anthrax cases during outbreaks was analyzed based on all the information obtained from farmers, community members, physician, health workers and mass media. It appears from Table 1 that 49.8% animals, 44.0% humans and 6.2% poultry birds were affected with anthrax. Chi-square analysis of the association between level of knowledge with age and education of respondents, either satisfactory or non-satisfactory reveals no any significant association (Table 2).

SN Parameters	Findings and analysis results				
1. Age (years)	Satisfactory	Non-satisfactory	Chi-square value	d.f.	P value
31-45	22	25	2.791	1	0.095
46-75	43	29			
Total	58	46			
2. Education					
Illiterate	22	25	2.791	1	0.095
Up to graduate	36	21			

DISCUSSION

Anthrax is considered an endemic zoonotic disease affecting animals, birds and humans in Bangladesh. The observation of anthrax in the then Bengal region has been reported in 1948.²⁰ and its occurrence has been mentioned in East Pakistan in 1961.²¹ The *Bacillus anthracis* the causative agent of anthrax has been isolated from an adult dead elephant of Mirpur Zoological garden.²² Then the occurrence of anthrax in 62 cattle and 27 humans in Pabna milk shed areas has been reported from Bangladesh in 1986.⁶ Followed by, 450 animal anthrax cases and 725 human cases have been reported during 1980 to 2010.⁵ The outbreaks of anthrax in animals and humans in Bangladesh during the period between 1982 and 2012 have been reviewed.⁴ During 2009 to 2012, more than 25 outbreaks of anthrax have also been reported simultaneously in

both cattle and humans and more than 650 human cases reported in 15 districts in Bangladesh.^{4,23} Analysis of 25 anthrax outbreaks in 414 human cases showed 91.30% cutaneous, 6.52% gastro-intestinal and 2.66% concurrent cutaneous and gastro-intestinal anthrax with a history of butchering sick animals, handling raw meat, contact with animal skin or present at the slaughtering sites.⁴ So far two human patients affected with anthrax died in two different outbreaks with symptoms of both cutaneous and gastro-intestinal forms of disease in Bangladesh.⁴ Since then repeated outbreak of anthrax has been reported in animals and humans every year from 16 districts of Bangladesh.^{9,24} However, poor knowledge, lack of awareness, improper carcass disposal, inadequate vaccination, high calcium content and moisture in the soil along with high ambient temperature and rainfall during the anthrax prone season have been reported as influencing factors for repeated outbreaks of anthrax in Bangladesh.²⁵ Due to lack of feed-back system in both the medical and veterinary medical practices, diseases of 'One Health' importance remain under-diagnosis and under-reporting in Bangladesh. However, only after human outbreak of anthrax that able to attract the mass media that makes the situation of reporting anthrax.

Two animal anthrax outbreaks in Sirajgonj district and one outbreak in Tangail district during April to June 2016 along with a single outbreak in Rajbari district in August 2017 have been reported in cattle.⁹ Pabna and Sirajgonj, two adjacent main milk producing districts with 47% reported human anthrax cases in 2010 have the highest cattle densities milk pockets in Bangladesh. Pabna, Sirajgonj and Tangail districts have been reported as apparently forming a spatial cluster that could be termed 'anthrax hotspot' in Bangladesh.¹⁶ History of heavy rains occurring in the last two weeks preceding an outbreak and disposing dead animals into nearby water body have been reported as the independent risk factors for anthrax in cattle in Bangladesh.¹⁶ This study recorded 209 anthrax cases based on questionnaire survey, of which 44.0% recorded in humans, 49.8% in animals and 6.2% birds that confirm the earlier reports on the occurrence clinical cases of anthrax during outbreaks in livestock and poultry birds.^{23,26,27}

Out of 169 samples (73 soil, 1 tissue, 4 bone and 91 bone meal) collected from 12 different districts of Bangladesh, of which 12 samples (10 soil and 2 bone) resulted positive for *B. anthracis* and two of them were previously identified in the district of Sirajgonj.¹⁰ Bangladesh soil conditions, together with ambient temperature and rainfall, represent an ideal situation for the spread of *B. anthracis*. The persistence of *B. anthracis* in Bangladesh soils is related to a lack of knowledge about disposing the dead animals and butchering sick animals and disposing of butchering wastes. Sick animals are usually slaughtered to minimize their economic loss and some people purchase the relatively cheap meat from these animals. During outbreak periods, the supplies of hides to the 60 tanneries fall sharply, affecting tannery owners and the 70,000 tannery workers in the country.⁸ All the identified affected human cases have been reported with a history of contact with the animal slaughtered carcasses or handling / processing with infected meat.⁷⁻⁸

Grazing and feeding of grass of contaminated soil of anthrax enzootic areas might be affected the animals. In addition, feeding of animals with uprooted, unwashed grass and water hyacinth have been reported as independent risk factors for anthrax in cattle in the districts of Pabna and

Sirajgonj of Bangladesh.¹⁵ Most of the human anthrax outbreaks have been reported to be associated with slaughtering of sick or moribund animals, presence and contributing at slaughtering and handling raw meat and meat products.⁶

Burning and buried are the two recognized methods for disposal of dead animals but due to economical ground and the level of awareness of the hazards of improper disposal of anthrax infected dead animals, they are usually either thrown in the flood or river water or in the open field, which results in contamination of the grazing land with anthrax spores.^{25,28} Anthrax bacillus sporulate rapidly on exposure to air and high temperature (>20 °C) and their survival is secured at least up to 60 years.²⁸⁻³¹ As a result, more animals acquire anthrax by ingestion of spores while grazing and the cycle of infection from carcass to grazing land continues. The social, managerial and environmental factors positively influence the repeated outbreak of anthrax in livestock and humans in Bangladesh. Slaughter of sick animals is influenced by economic considerations on the part of the animal owners, as well as the neighbors and other villagers who purchase the meat. Cattle owners slaughter moribund animals to minimize financial loss as a result of death of the animal, while people living in pervasive poverty in rural Bangladesh, and being unaware of the risks associated with slaughtering, handling or eating meat of sick animal, purchase the relatively inexpensive infected meat.⁹ Such strong economic stimulation in favor of slaughtering sick animals suggests that a prevention strategy that only encourages people not to slaughter sick animals and to bury anthrax infected dead animals deep in the ground is unlikely to be successful.²⁴

Active immunization is the only known method of preventing anthrax in herbivorous animals in areas where the pasture land is already contaminated with anthrax spores^{5,29,30} and improper and inadequate use of anthrax spore vaccine with lack of monitoring system resulted in anthrax being enzootic among livestock and humans in Bangladesh.²⁵ It appears that the anthrax is a neglected tropical zoonotic disease associated with negative impacts at the rural household level due to causing clinical disease and production loss in livestock as well as severe disease in humans. This study confirms that anthrax has not yet been appropriately prioritized in Bangladesh. This study also confirms that the anthrax is a human and animal health hazard associated with death and socio-economic crisis in at least 16 districts with major in the Sirajgonj district. This indicates that there is no program on the prevention and control of anthrax in this district either coordinated by the government or international organizations.

This investigation based on the interview of 104 randomly selected populations of which approximately 45.2% illiterate populations without any formal education and this survey included 51.9% smallholder farmers, and overall 44.2% respondent did not know about the disease. However, comparatively higher percentage of people (93.0%) have been reported without any knowledge on anthrax whereas 40.0% reported that they heard the name of anthrax or 'Torika' (Bangla name).⁹ Respondents in another investigation reported that moribund animals were typically butchered and the waste products were discarded in nearby rivers, ditches, bamboo bushes or on privately owned land.²⁷ It seems that education influences one's access to information and ability to comprehend health messages. Involvement of an educated family member in farming practices can create awareness and improve knowledge about zoonotic disease and 'One Health' program.³²

Lack of awareness about the diseases transmitted between animals and humans and vice-versa especially anthrax might be due to poor communication between veterinary medical practitioners and physicians (One Health program) and lack of involvement of educated family members in farming activities. Moreover, there is no government and One Health program to make aware the rural farmers about the impact of zoonotic diseases in Bangladesh.

The socio-economic factors especially poverty could affect a practice of proper disposal of dead carcasses and slaughtering of moribund disease affected animals for human consumption. Therefore, the essential feature of fundamental socio-economic causes involves access to resources like money, education, knowledge, attitude, awareness, practices, powers, prestige that can be used to avoid risks or to minimize the consequences of the zoonotic diseases.

CONCLUSIONS

There was no consistent understanding of the disease among the participants and the participants did not get any consistent, adequate and continuous health information regarding the zoonotic disease especially anthrax. The socio-economic factors impacted the KAP of the community towards the disease. The information obtained from this investigation has involved and presented to decision makers, used to build technical capacity of veterinary medical services to foster a 'One Health' approach to the prevention and control of zoonotic diseases. The control of anthrax in humans depends on the control of infection in animals. Veterinary medical services should be strengthened in the endemic areas especially for close surveillance and reporting, burying or cremation of dead animal carcasses and decontamination and disinfection procedures. A continued infection control educational program for animal owners and local residents as well as immunization of animals against anthrax with monitoring and feed-back system would help to prevent and control the infection in endemic areas.

ETHICAL APPROVAL

Ethical approval was not required in the questionnaire survey based study however, data were collected after obtaining consent from all the respondents.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

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REFERENCES

1. Inglesby TV, Henderson DA, Bartlett JG, Ascher MS, Eitzen E, Friedlander AM, Hauer J, McDade J, Osterholm MT, O'Toole T, Parker G, Perl TM, Russell PK and Tonat K (1999). Anthrax as a biological weapon: *Medical and public health management. Journal of American Medical Association* 282: 1735-1740
2. Dutta T, Sujatha S and Sahoo R (2011). Anthrax-update on diagnosis and management. *Journal of Association of Physicians India* 59: 573-578

3. WHO (2008). Anthrax in humans and animals. 4th edn., Geneva, Switzerland.
4. Samad MA (2011). Public health threat caused by zoonotic diseases in Bangladesh. *Bangladesh Journal of Veterinary Medicine* 9: 95-120
5. Ahmed B, Sultana Y, Fatema DSM, Ara K, Begum N, Mostanzid SM and Jubayer S (2010). Anthrax: An emerging zoonotic disease in Bangladesh. *Bangladesh Journal of Medical Microbiology* 4: 46-50
6. Samad MA and Haque ME (1986). Anthrax in man and cattle of Bangladesh. *Journal of Tropical Medicine and Hygiene* 89 : 43-45
7. Siddiqui MA, Khan MAH, Ahmed SS, Anwar KS, Aktaruzzaman SD and Salam MA (2012). Recent outbreak of cutaneous anthrax in Bangladesh: Clinico-demographic profile and treatment outcome of cases attended at Rajshahi Medical College Hospital. *BMC Research Notes* 5, 464 [doi: 10.1186/1756-0500-5-464]
8. Islam MS, Hossain MJ, Mikolon A, Parveen S, Khan MSU, Haider N, Chakraborty A, Titu AMN, Rahman MW, Sazzad HMS, Rahman M, Gurley ES and Luby SP (2013). Risk practices for animal and human anthrax in Bangladesh: an exploratory study. *Infection Ecology and Epidemiology* 3 :1-9, 21356 [doi: 10.3402/iee.v3i0.21356]
9. Islam SKS, Chakma S, Akhter AHMT, Ibrahim N, Talukder F and Chowdhury GA (2018). Investigation of animal anthrax outbreaks in the human-animal interface at risky districts of Bangladesh during 2016-2017. *Journal of Advanced Veterinary and Animal Research* 5: 397-404 [doi 10: 5455/javar.2018.e290]
10. Rume FI, Affuso A, Serrecchia L, Rondinone V, Manzulli V, Campese E, Taranto PD, Biswas PK, Ahsan CR, Yasmin M, Fasanella A and Hugh-Jones M (2016). Genotype analysis of *Bacillus anthracis* strains circulating in Bangladesh. *PLoS ONE* 11(4): e0153548 [doi: 10.1371/journal.pone.0153548]
11. Muturi M, Gachohi J, Mwatondo A, Lekolool I, Gakuya F, Bett A, Osoro E, Bitek A, Thumbi SM and Munyua P (2018). Recurrent anthrax outbreaks in humans, livestock and wildlife in the same locality, Kenya 2014-2017. *American Journal of Tropical Medicine and Hygiene* 99: 833-830
12. Sitali DC, Twambo MC, Chisoni M, Bwalya MJ and Munyeme (2018). Lay perceptions, beliefs and practices linked to the persistence of anthrax outbreaks in cattle in the Western Province of Zambia. *Onderstepoort Journal of Veterinary Research* 85: 1-8
13. Fasanella A, Garofolo G, Hossain MJ, Shamsuddin M, Blackburn JK and Hugh-Jones M (2012). Bangladesh anthrax outbreaks are probably caused by contaminated livestock feed. *Epidemiology and Infection* 141: 1021-1028 [doi: 10.1017/S0950268812001227]
14. Romha G and Girmay W (2020). Knowledge, attitude and practice towards anthrax in Northern Ethiopia: a mixed approach study. assets.researchsquare.com [doi: 10.21203/rs.3.rs-33998/v3]

15. Biswas PK, Islam MJ, Shil SK, Chakraborty PK, Ahmed SSU and Christensen JP (2012). Risk factors associated with anthrax in cattle on small holdings. *Epidemiology and Infection* 140: 1888-1895 [doi: 10.1017/S0950268811002408]
16. Rume FI, Karim MR, Ahsan C, Yasmin M and Biswas PK (2020), Risk factors for bovine anthrax in Bangladesh. 2010-2014: a case-control study. *Epidemiology and Infection* 148: 1-12 [doi: 10.1017/S0950268820000576]
17. Rambhia K (2010). Anthrax outbreak in Bangladesh. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice and Science* 8: 300-301
18. Mwakapeje ER, Hogset S, Softic A, Mghamba J, Nonga HE, Mdegela RH and Skjeve E (2018). Risk factors for human cutaneous anthrax outbreaks in the hotspot districts of northern Tanzania: an unmatched case-control study. *Royal Society of Open Science* 5: 180479
19. Opare C, Nsiire A, Awumbilla B and Akanmori B (2000). Human behavioral factors implicated in outbreaks of human anthrax in the Tamale municipality of northern Ghana. *Acta Tropica* 76: 49-52
20. Mohan RW and Ali SM (1948). Some aspect of anthrax in Bengal. *Indian Journal of Veterinary Science* 8:1
21. Khaleque KA, Muzazzam MG and Chowdhury RI (1961). Anthrax in East Pakistan. *Journal of Tropical Medicine and Hygiene* 64: 18-19
22. Mustafa AH (1984). Isolation of anthrax bacillus from an elephant in Bangladesh. *Veterinary Record* 114(24): 590
23. Chakraborty A, Khan SU, Hasnat MA, Parveen S, Islam MS, Mikolon A, Chaktaborty RK, Ahmed B, Ara K, Haider N, Zaki SR, Hoffmaster AR, Rahman M, Luby SP and Hossain MJ (2012). Anthrax outbreak in Bangladesh, 2009-2010. *American Journal of Tropical Medicine and Hygiene* 86: 703-710 [doi: 10.4269/ajtmh.2012.11-0234]
24. ICDDR (2010). Anthrax outbreaks in Bangladesh: an update. *Health and Science Bulletin* 8 : 1-7
25. Hassan J, Ahsan MM, Rahman MB, Chowdhury SMZH, Parvej MS and Nazir KHMNH (2015). Factors associated with repeated outbreak of anthrax in Bangladesh: qualitative and quantitative study. *Journal of Advanced Veterinary and Animal Research* 2: 158-164
26. Islam SKS, Castellan DM, Akhter AHMT, Hossain MM and Hasan MZ (2015). Animal anthrax in Sirajganj district of Bangladesh from 2010 to 2012. *Asian Journal of Medical and Biological Research* 1 : 387-395
27. Islam S, Hasan SMM, Haque F, Haider N, Hossain MB, Uddin ASS, Rahman M, Salzer JS, Kadzik M, Kennedy E and Gurley ES (2017). Human exposures to by-products from anthrax infected animals in Bangladesh. Conference paper: ISES Annual meeting, USA Oct 15-19

28. Roy P, Rashid MM, Ferdoush MJ, Dipti M, Chowdhury MGA, Mostofa MG, Roy SK, Khan MAHNA and Hossain MM (2013). Biochemical and immunological characterization of anthrax spore vaccine in goat. *Bangladesh Journal of Veterinary Medicine* 11 : 151-157
29. Ahsan MM, Khan MFR, Rahman MB, Hasan J, Chowdhury SMZH, Parvez MS, Jahan M and Nazir KHMNH (2013). Investigation into *Bacillus anthracis* spore in soil and analysis of environmental parameters related to repeated anthrax outbreak in Sirajgonj, Bangladesh. *Thailand Journal of Veterinary Medicine* 43 : 449-454
30. Dipti M, Rashid MM, Ferdoush MJ, Roy P, Khan MAHNA and Hossain MM (2013). Morphological and immunological characterization of anthrax vaccine in cattle. *Bangladesh Journal of Veterinary Medicine* 11 : 43-49
31. Nazir KHMNH, Hassan J, Chowdhury SMZH and Rahman MB (2015). Novel multiplex-PCR for rapid detection of *Bacillus anthracis* spores present in soils of Sirajganj district in Bangladesh. *Progressive Agriculture* 26 : 67-70
32. Rajkumar K, Bhattacharya A, David S, Balaji SH, Hariharan R, Jayakumar M and Balaji N (2016). Socio-demographic study on extent of knowledge, awareness, attitude and risks of zoonotic diseases among livestock owners in Puducherry region. *Veterinary World* 9 : 1018-1024 [doi: 10.14202/vetworld.2016.1018-1024]