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Outbreak of *Salmonella* in poultry of Bangladesh and possible remedy

Md. Najmol Hoque[1], Rasha Binte Mohiuddin[2], Mohammad Mehedi Hasan Khan[1*], Afsana Hannan[3], Md. Jahangir Alam[4]

[1]Department of Biochemistry and Chemistry, Sylhet Agricultural University, Sylhet, Bangladesh; [2]University of Hohenheim, Germany; [3]Department of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh; and [4]Department of Animal Production & Management, Faculty of Animal Science and Veterinary Medicine, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

[*]Corresponding author: Dr. Mohammad Mehedi Hasan Khan, Department of Biochemistry and Chemistry, Sylhet Agricultural University, Sylhet, Bangladesh, Email: mehedi2001bdbd@gmail.com

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ABSTRACT: Poultry sector is presently emerged as a great profitable sector in worldwide. The sector's role in the immense development of the people related this sector. Eggs and hens of layer farms are a major protein source for the people in Bangladesh. Different types of zoonotic diseases prevent the development of the sector. Among the major anxiety related to the development are health issues that scolding not only animal production, but also the community using the food resulting from these animals. One of the most frequently and widely occurring disease is Salmonella. Small-scale commercial farms are predominating here as in Bangladesh where stocks range from several hundreds to thousands and kept in a semi-confined system with a minimum of bio security. In such a system, the birds might be more vulnerable to become exposed to *Salmonella*. Rainy season is the most suitable for salmonella infection then summer or winter. Prevalence of *Salmonella* spp. was significantly higher in egg shell compared to egg contents are associated with human illnesses during consumption of contaminated poultry eggs. Different survey notified that, salmonella occurrence in Bangladesh ranges from 20% to above 90% in different locations and seasons. Animals are recognized to be the major reservoir for salmonellae; modern methods of animal husbandry, food production and food handling may encourage the transmission of these organisms from animal products to man. Efforts including critical control point programs in food manufacture are needed to reduce the incidence of *Salmonella* in food. Consumers-awareness efforts would protect public health from foodborne Salmonellosis.

KEYWORDS: Salmonellosis, Poultry, Zoonotic Disease, Season.

INTRODUCTION

Diseases and infections shared between animals and humans are mainly called zoonotic diseases which may be categorized as emerging, reemerging and neglected [1]. All types of these diseases occur throughout the world including Bangladesh. Poultry production is considered one of the fastest growing livestock industries, as a result of its amenities in terms of ground use and elevation in the food shift rate of genetically superior poultry breeds. Among the major anxiety related to this development are health issues that scolding not only animal production, but also the community using the food resulting from these animals. The food-born zoonotic disease Salmonellosis in humans and animals of Bangladesh are analyzed from the published literatures and presented in this report. It appears from the journalism that there are about 1415 human pathogens of which 61% are zoonotic and most of the human pathogens can be classified as emerging, of which 75% of these are caused by zoonotic pathogens [1]. From these results it seems that all types of emerging, reemerging and neglected zoonotic diseases are widely prevalent and pose a great threat to human health in Bangladesh [1]. Ignorance of Veterinary medical profession and its extension services, poor people without any knowledge of zoonotic diseases who are in close contact with livestock and their products and

unhygienic processing, maintaining and marketing the livestock and livestock products have made the situation graver in Bangladesh [1].

Animals are recognized to be the major reservoir for salmonellae; modern methods of animal husbandry, food production and food handling may encourage the transmission of these organisms from animal products to man. *Salmonella* is a major food-borne pathogen worldwide and contaminated poultry product, especially undercooked meat and uncooked eggs are important sources of it. Eggs and hens of layer farms are a major protein source for the people in Bangladesh. Small-scale commercial farms are predominating here as in the other South and South-East Asian countries where stocks range from several hundreds to a few thousands, kept in a semi-confined system with a minimum of bio security. In such a system, unlike large-scale commercial production systems seen in developed countries, the birds might be more vulnerable to become exposed to *Salmonella* [2]. In future, it is needed to consider the variations in the epidemiologies of food-borne zoonotic infections and apply a quantitative risk analysis approach to ensure that the most cost-effective programs are developed. Balanced use of antibiotics needs to be adopted in commercial poultry farming system of Bangladesh to prevent the emergence of drug-resistance *Salmonella* to protect the public health consequences [3].

MAJOR ZOONOTIC DISEASES IN BANGLADESH

The most important zoonotic bacterial diseases recorded in Bangladesh are Anthrax, Tuberculosis, Brucellosis, Salmonellosis, Campylobacteriosis and Leptospirosis of which only Anthrax has been reported as clinical outbreaks form in both the humans and cattle [1]. During the period 2009 to 2012, anthrax caused death of hundreds of cattle and more than 650 cases of cutaneous anthrax in humans including fatalities in two humans associated with anthrax [1]. The major reported viral zoonotic diseases in Bangladesh include avian influenza, Rabies, Nipah virus infection, Japanese encephalitis, Rotavirus and Dengue fever. Avian influenza caused by highly pathogenic H5N in humans and poultry in Bangladesh and about six humans affected with H5N but all of them have recovered. Since 27 March 2007 when Avian influenza was reported to have occurred for the first time in Bangladesh, this virus spread in 51 out of 64 districts with more than 480 outbreaks, culled more than two million poultry birds and cost Tk. 55 billion (US $ 757.9 million) in Bangladesh. Rabies is considered as a significance zoonosis in Bangladesh and it is mainly transmitted to humans and animals food [28]. Through dog bite nearly 100,000 people and at least 2000 died of rabies in 2009 in Bangladesh. Nipah virus infection is recognized as vital emerging infectious disease (63.58%) died in 2001 in Bangladesh [1]. Japanese encephalitis (JE) is a vector borne zoonotic disease, first detected in Bangladesh since an outbreak in 1977 and 12.38% encephalitis patients had JE virus infection which was associated with mortality, physical disability and cognitive difficulties [1].Rotavirus is a worldwide distributed zoonotic disease affecting mammals and birds and it has been reported from Bangladesh in humans (23.75%), animals (12 to 43.78%) and broiler birds (13.15%) linked with diarrheic syndrome. Dengue fever was first reported in Bangladesh in 1964 and outbreak that began in 2000 predominantly caused by DENV-3 in which 5551 cases recovered and 93 Dengue related deaths were reported. The dermatomycosis has been reported in 9.3% cattle, 18.6% goats and 25.2% in contact humans [1].

SALMONELLA

Salmonella is a prominent water/foodborne fecal-oral zoonosis world wide [64, 65] is rod-shaped bacteria of the Enterobacteriaceae family [4, 5] related to Escherichia and Shigella [66]. *Salmonella* was named after medical research scientist Theobald Smith who was working as a research laboratory assistant under Veterinary Division of the United States Department of Agriculture [6, 22]. Generally, there are two species of *Salmonella*: *Salmonella bongori* and *Salmonella enterica* of which have six subspecies and in several serovars [7]. Salmonellae are found commonly in both cold-blooded and warm-blooded animals and environments [8]. They cause sicknesses such as typhoid fever, paratyphoid fever and food poisoning [7]. *Salmonella* are non-spore forming, mostly motile typed enterobacteria with diameters near about 0.7 to 1.5 μm, lengths from 2 to 5 μm, and having peritrichous flagella. They are chemo-organotrophs, obtain their energy from the oxidation and reduction reactions using organic sources and are facultative anaerobes [5, 9, 10]

It`s taxonomy has been revised and has the likely to confuse [3, 7]. The taxonomic group covers more than 2500 serovars based on the somatic and flagellar H antigens [3, 7]. The full name of a serovaris *Salmonella enterica sub sp*. Enteric serovar Typhimuriu that can be shortened to *Salmonella typhimurium* [10, 11]. Strains variations may be achieved by antibiogram and subgenomic techniques such as Pulsed Field Gel Electrophoresis (PFGE), Multi-Locus Sequence Typing (MLST) and by Whole Genome Sequencing (WGS) to support clinic epidemiological investigation [10]. Based on host preference and disease manifestations in man, the Salmonellae have been clinically categorized as

invasive (typhoidal) or non-invasive (non-typhoidal Salmonellae) [12].A strain of *Salmonella* that has been spreaded in the United States is *Salmonella javiana*. Increasing number of *Salmonella* serotypes that were Multidrug Resistant (MDR) was identified by the CDC's National Antimicrobial Resistance Monitoring System [13, 21]. Contamination with non typhoidal serovars of *Salmonella* results in food poisoning [3]. Infection generally occurs when a person ingests foods that contain a high concentration of the bacteria where infants are more susceptible to infection [3].

Salmonella is a significant reason of infection, affecting both humans and animals [14]. It is the causal agent of salmonellosis, a gastrointestinal disease of public health impact [15]. Some *Salmonella* strains that exist in humans can make animals' ill, and vice-versa [43]. This bacterium survives in the gut of infected humans and animals. The organism enters through the digestive tract and cause disease in healthy adults. Infectious processes can occur after living salmonellae reach the gastrointestinal tract [67]. Some of the microorganisms are killed in the stomach, while the surviving salmonellae enter the small intestine and multiply in tissues [16]. Gastric acidity is responsible for the destruction of major ingested bacteria; however *Salmonella* has evolved a level of tolerance to acidic environments that allows subsequent ingested bacteria to survive [16]. Bacterial colonies may become trapped in mucus produced in the oesophagus. With the end of the incubation period, the nearby cells are poisoned by endotoxins released from the dead salmonellae. The local response to the endotoxins is enteritis and gastrointestinal disorder [16].

SALMONELLOSIS

Salmonellosis is a typical zoonotic disease that occurs frequently in poultry flocks [17]. It is a disease caused by *Salmonella*. People who consume *Salmonella* contaminated unhygienic food can become ill with salmonellosis. The disease is more common in summer than in winter [69]. Like other foodborne illnesses, the symptoms of salmonellosis can feel like stomach flu, but they can also develop into serious illness with long-lasting effects. Salmonellosis is a common illness in many developing countries, including Bangladesh. Hens and eggs produced from layer farms are a major source of protein for the people in Bangladesh [2]. *Salmonella* contamination is one of the most critical restrictions in poultry farming that has slowed down its development in Bangladesh [25]. *Salmonella* serotypes with multidrug resistant phenotypes are a threat to the poultry of Bangladesh [26]. *Salmonella* is a globally extensive food-borne pathogen having major impact on public health. Every motile serovars of *Salmonella enterica* of poultry derivation are zoonotic and contaminated meat and raw eggs are a significant source to human infections. The prevalence of *Salmonella* at farm holding level are increasing day by day in Bangladesh where small-scale commercial farms are predominant [2].

Salmonella infection is one of the most concerning problems for poultry industry in Bangladesh that have public health importance [27-28]. *Salmonella pullorum* causes the disease pullorum, which is transmitted vertically from parent to offspring [23]. Fowl typhoid, caused by *Salmonella gallinarum*, is an acute or chronic disease that most often affects mature birds and is a serious problem resulting in mortality and lowered egg production and hatchability. *Salmonella gallinarum* can create lesions in chicks, vague from those associated with Pullorum disease. In this study, data on salmonellosis has taken from different location of Bangladesh like, Mymensingh, Gazipur, Savar, Tangail, Rajshahi, Patuakhali, Sylhet regions and Cox`s Bazar district. Location wise occurrence of *salmonella* in Bangladesh is shown in Fig 1.

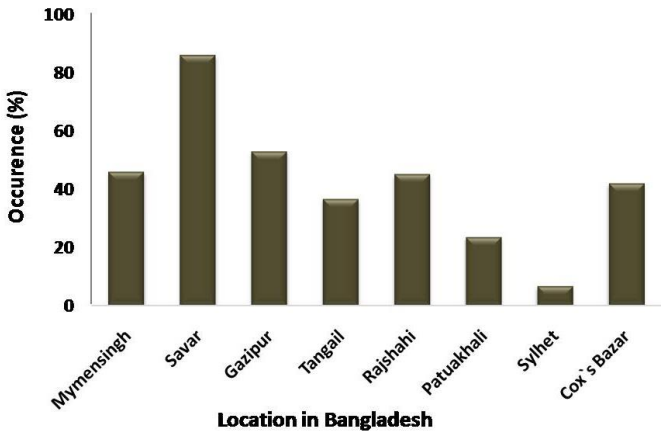

Figure 1. Location wise occurrence of *Salmonella* in Bangladesh.

The seroprevalence of *Salmonella* infection is 45.9% in layer birds at Mymensingh district [29-30]. Village chickens can act as a reservoir of salmonellosis. In Tangail districts of Bangladesh, 20.4% samples have found positive for *Salmonella* species in 2010, [31] 36.67% incidence of *Salmonella* species in 2015 [32]. Again 28.57% of *Salmonella* species were positive in transport swabs samples, 28.57% in feed samples and 18.75% in water samples in Tangail district of Bangladesh [33-35]. Salmonellosis is the most prevalent disease followed by infectious bursal disease and mycoplasmosis in different kinds of poultry of Gazipur district of Bangladesh. The diseases encountered in layers were bacterial diseases 52.29% where salmonellosis was 38.56%. In case of broiler, bacterial

disease 28.99% among this salmonellosis was 21.30% [36-37].

The prevalence of *Salmonella sp.* in poultry eggs from different retail markets of Savar was 86% in poultry eggs (83% from outer shell of eggs and 3% from egg contents) and was higher in spring (91%) than in winter (82%) [38]. Prevalence of *Salmonella sp*. was significantly higher in egg shell compared to egg contents and may be associated with human illnesses during consumption of contaminated poultry eggs. In a serological survey on the prevalence of *Salmonella sp*. in Rajshahi and surrounding districts was 45.1%. Predominance of *Salmonella* was recorded the highest (37.6%) in adult compared to young (16.7%). For season wise highest was in summer (30.4%) followed by winter (23.7%), rainy (25.0%) and autumn (23.3%) [39].The Seroprevalence of *salmonella* infection in six model breeder poultry farms (MBPFS) at Patuakhali district reported *Salmonella* infection was 23.46% which was highest in rainy season (25.0%) than the winter season (21.88) [40].

In pathological investigation on the occurrence of poultry diseases in Sylhet region of Bangladesh was performed in 2003 [39].In this study Salmonellosis was found 6.73%, where highest number of *Salmonella sp.* in the age group of 8-21 days followed by 22-35 days age group, 36-60 days age group and over 60 days age group of Poultry [39].

Recently, rapid serum plate agglutination test for *Salmonella* identification was done in Cox`s Bazar where 42% chickens were found positive for *Salmonella* infection [62]. Seroprevalence was higher in adults (68%) compared to young 20% chickens [63]. Age dependent occurrence of *Salmonella* in Cox's Bazar and Rajshahi is shown in Fig 2.

According to several researches distribution and proportionate incidence of poultry disease of Bangladesh reveals that the poultry diseases occur mostly in rainy season followed by summer and the least in winter season [38, 40-41]. Season wise occurrence of *Salmonella* in Bangladesh is shown in Fig 3. Transmission is primarily through the egg but also via direct or indirect contact with infected birds. Infection transmitted via egg or hatchery contamination usually results in death up to 2-3 weeks of age. The birds that survive clinical disease when infected at a young age may show few signs of infection but can act as carriers. Environmental factors such as air, dirty litter and unclean facilities, and vectors, such as insects, humans, and rodents are responsible for *Salmonella* contamination in poultry farms. The prevalence of salmonellosis in breeder flocks and specially layer flocks is increasing in Bangladesh [40-41].

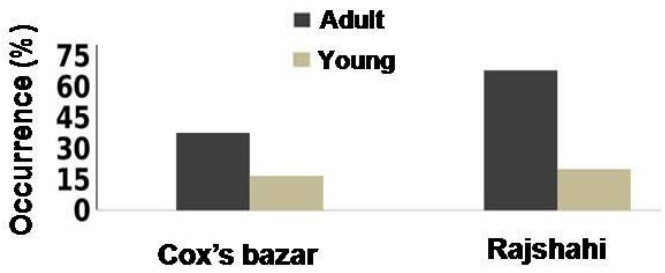

Figure 2. Age dependent occurrence of *Salmonella* in two regions in Bangladesh

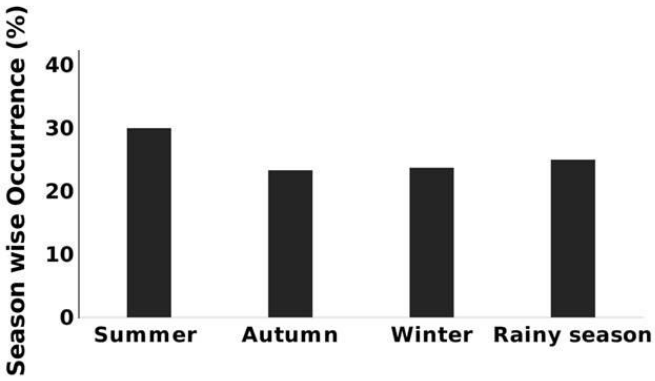

Figure 3. Season wise occurrence of *Salmonella* in Bangladesh

RISK FACTORS

Salmonella infections are life-threatening especially for infants, pregnant women and their unborn babies [18]. But it can be prevented, if foods are cooked average 68–72°C (145–160°F), and liquids such as soups or gravies must be boiled. Freezing kills *Salmonella*, but it is not sufficient to reduce *Salmonella* below infectious levels. *Salmonella* is typically heat-sensitive; it does acquire heat resistance in high-fat environments such as peanut butter. Vaccines are available for typhoid fever but no vaccines are available for non-typhoidal salmonellosis [68]. Generally, Salmonellosis treatments replace fluid loss by oral and intravenous route antibiotic administration. Typhoid fever and enteric fevers should be treated with antibiotics [19].

THE GLOBAL BURDEN OF *SALMONELLA*

Most people experience at least one episode of food poisoning during their lifetime. Among foodborne bacterial diseases salmonellosis causes huge economic losses in terms of massive morbidity and mortality. Food borne *Salmonella* is estimated to cause approximately 10.9 million illness, 116.8 thousands [70] deaths in the year of 2017 in the world. In the USA, it was estimated

that one in ten people was experienced bacteria-related food poisoning each year, of which the majority will be associated with *Salmonella* or Campylobacter [3]. Similarly, a recent national surveillance study in England revealed that one in five people developed infectious intestinal disease each year and that Campylobacter and *Salmonella* were the most common bacterial pathogens isolated. Bacterial food-borne zoonotic infections are the most common cause of human intestinal disease in many countries of the world. *Salmonella* and Campylobacter account for over 90% of all cases of bacteria-related food poisoning world-wide [20]. Poultry and poultry products incriminated in the majority of traceable food-borne illnesses caused by these bacteria are reservoirs of infection. *Salmonella enteritidis* caused pandemic in both poultry and humans during the final half of the 20th Century. *Salmonella typhimurium* and *Campylobacter* appeared more ubiquitous in the environment, colonising a greater variety of hosts and environmental niches [20]. Outbreaks and sporadic cases of salmonellosis are frequently associated with the intake of infected hen eggs with *Salmonella sp*. The disease is endemic in many developing countries, particularly the Asian subcontinent and South and Central America [3]. Antibiotic used as a therapeutic, prophylactic, or growth promoter of poultry in many developing countries including Bangladesh which deposit residues in meat and eggs. The emergence of antimicrobial-resistant, *Salmonella* strains is of great concern and emerging antimicrobial resistance has become a public health issue worldwide [21]. There are reports of high prevalence of resistance in *Salmonella* isolates from countries such as Bangladesh, India, and France. Similarly, there are various reports of multidrug-resistant *Salmonella* organisms isolated from chickens eggs in Bangladesh. In recent years, antibiotic resistance in *Salmonella* has assumed alarming issue, and most of the *Salmonella* isolated from layer birds detected earlier as are resistant to at least one antimicrobial. The eggshell surface contamination can occur through egg contact with fecal material, and feed or even during transportation, storage or handling. The results of researches indicated that the prevalence of *Salmonella* in eggshell surface is significantly higher [22].

The prevalence of *Salmonella* was reported 40% in eggshells in a previous study carried out in Pakistan and 6.1% in India [23]. One possible cause of *Salmonella* contamination in developing countries is repeated use of same egg-storing trays. Egg-storing trays contamination might be due to chicken fecal material or due to the environmental factors [23]. The results of *Salmonella* incidence in commercial egg-storing trays were 7.5% in India. Moreover, antibiotic treatment is considered the most important issue that promotes the emergence, selection and spreading of antibiotic-resistant microorganisms in both veterinary and human medicine. Evidence indicated that antimicrobial resistance among human Salmonellasis results from the presence of antimicrobials residues in the foods. *Salmonella* species are a principal bacterial cause of acute gastroenteritis. Although the global human health impact of *Salmonella* infections has not been estimated, gastroenteritis is a major cause of morbidity and mortality, worldwide, both in children < 5 years old and in the general population [23].

PREVALENCE AND MULTIDRUG RESISTANT PATTERN OF *SALMONELLA* IN BANGLADESH

Poultry seems to be one of the main reservoirs of *Salmonella sp*. in Bangladesh. The high level of contamination indicates an alarming situation, both for chicken farming and public health as well. A similar rate (25%) of *Salmonella sp.* was present in the samples from poultry and poultry environments in Bangladesh [42]. That study also reported that 25% of the cloacal swab samples and 50% of intestinal fluid samples were contaminated with *Salmonella sp*. *Salmonella* contamination was found 26% and 60% in cloacal swab and intestinal fluid samples, respectively. The occurrence of *Salmonella* contamination in samples from poultry sources has also been reported from various parts of the world; 17%, 35%, 36%, 39%, and 53% in USA, Spain, Korea, Brazil and Vietnam, consecutively [43-45]. The presence of *Salmonella sp.* in chicken handler indicated a potential breakdown of personal hygiene at the stage of chicken handling and processing. Studies have demonstrated that poultry feeds have been implicated as an important source of *Salmonella sp*. and may therefore be the consequence of the subsequent contamination of eggs [43]. However, egg surface might have been contaminated with *Salmonella sp*. with feces during lay in unhygienic condition from infected poultry. Among the animal protein ingredients, a major ingredient of poultry feeds, locally processed cheap fish wastes were found to be a vital cause for bacterial contamination of poultry feeds. Moreover, *Salmonella* was reported as a common microflora in animal feedstuffs, raw feeding materials and poultry feeds [45]. Careless and unhygienic handling process serves as a frequent source of contamination with *Salmonella* in pre-stuffed chickens in poultry shops. Poultry and poultry products like eggs and plastic-wrapped poultry meat found in various super shops and ready-to-eat foods become cross contaminated with *Salmonella sp.* and other pathogenic bacteria from food handlers with poor personal hygiene

and may be from other raw poultry products. In addition, several study confirmed a high incidence of antibiotic resistance with the frequency of 20% to 100% among *Salmonella sp*. isolated from poultry and poultry environments in Bangladesh. *Salmonella* strains isolated from poultry sources were commonly resistant against ampicilin, tetracycline and chloramphenicol and susceptible to nalidixic acid and gentamicin as found in several studies in Bangladesh. Resistance against penicilin, ampicilin, tetracycline and erythromycin was often observed due to low cost, ready availability and for drug abuse [44, 45]. Therefore, prudent use of antimicrobials in animal production system has been accepted worldwide as a means of preventing development of the antimicrobial resistance in pathogenic bacteria. Moreover, all the isolates exhibited multidrug resistance against more than five antibiotics. Similar findings on multidrug resistance among *Salmonella* strains have been reported from Bangladesh and various parts of the world [44]. The ability of bacteria to acquire antibiotic resistance gene and subsequently spread them to many different bacterial species is now well known. Integrons play an important part in the transfer of resistance among *Salmonella* serotypes to a variety of antimicrobial drugs. Several surveys on antibiotic operation in Bangladesh have revealed that peoples are in the habit of consuming antibiotics familiarized in frequent uptake of antibiotics than necessary and antibiotics can be bought here easily from drugstores without any prescription. It may facilitate the development of multidrug resistant pathogens, as regular exploit of antimicrobials would put selective pressure for development and proliferation of resistance genes. In addition, low cost and available antimicrobials like ampicillin, penicillin, tetracycline and erythromycin are frequently used as growth promoters or feed additives or preservatives to the food producing animals and poultry flocks to assuage the escalating food requirements for the augmented population in Bangladesh. The results of the study have illustrated the extent of antibiotic resistance in *Salmonella* serotypes from poultry sources in Bangladesh. The domestic and commercial handlers of poultry and poultry products in chicken shops and household and the peoples engaged in the poultry farms need more attention to strictly follow the rules and guidelines of hygiene to reduce or eliminate the risk of antibiotic resistant *Salmonella* and other pathogenic microbes. In addition, the use of antibiotics both for farming and for medication should be astute to minimize the chance for organisms to develop resistance. Salmonellosis is one of the major bacterial agents that cause foodborne infections in humans worldwide. The majority of salmonellosis outbreaks have been attributed to food such as eggs, chicken, beef, and fish to human carriers. The outbreaks involving eggs, approximately all have occurred in the food service sector and have been the result of inadequate refrigeration and insufficient cooking. Salmonellosis is a major problem in layer poultry in Bangladesh and its prevalence ranged from 28% to 53.3% [2]. The fatality rate in people infected with antibiotic-resistant *Salmonella* is 21 times greater than that infected with non-antibiotic-resistant *Salmonella* strains. Different serotypes of *Salmonella* including *Salmonella typhimurium* and *Salmonella enteritidis* are prevalent both in poultry and human and categorized as zoonotic pathogens. *Salmonella sp*. contamination in egg producing farms and market outlets may arise at any production stage by horizontal or vertical transmission. One probable cause of *Salmonella* contamination in developing countries is reusable egg trays [2]. Outbreaks and sporadic cases of salmonellosis are frequently associated with the intake of infected hen eggs with *Salmonella sp*. Multidrug resistance of *Salmonella sp.* has increased in developing countries with the indiscriminate use of antibiotics in the poultry production system [26]. *Salmonella* isolates showed multidrug-resistance pattern up to five of the eight antimicrobials tested [3].

Therefore, widespread availability and uncontrolled use of antibiotics poses the antimicrobial resistance in food animals and their products which are the actual threat of public health.3 Multidrug-resistant *Salmonella typhimurium* was already reported in the past few decades and was frequently reported from the Indian subcontinent. Ongoing infection with *Salmonella* organism and use of medication at breeder level could significantly amplify the prevalence of multiple resistant *Salmonella* in poultry rearing environment in Bangladesh [3].

The results indicated that *Salmonella*-contaminated eggs are common in the retail markets of Bangladesh. The poor storage and handling practices of eggs at the site of sale might be a source of contamination. The excess utilization of antibiotics in the poultry farms might be the cause of increased resistance. Balanced use of antibiotics in animal production and more careful use of drugs in humans are needed. It is important to take concentrated action to improve antibiotic resistance inspection worldwide with a view to monitoring the promising resistance genes and their transfer in both animal and human. Therefore, from above discussion based on references, *Salmonella* organisms were present in poultry egg and its environment and showed different antibiotic resistance pattern which may cause a serious public health problem in our country.

CAUSES OF SALMONELLOSIS

Raw meat is a major cause of Salmonellosis. *Salmonella* exist in the guts of birds, humans and animals. Mostly, human contaminations are caused by eating food or drinking water that has been polluted by feces (dirt). Foods that are most frequently infected according to Mayo [46] USA: Uncooked meat, seafood and poultry dirt commonly occurs during the slaughtering process [47]. Unprepared eggs shell may appear to be a great obstacle to contamination. Some unhygienic chickens may produce eggs that contain *Salmonella* prior to the shell is yet formed. We eat fruits and vegetables, if fruits and vegetables are watered or washed in unhygienic water there is a much higher chance of contamination. Again, if the human being prepares the food managing raw meat and then touches the fruit devoid of washing hands it will create the chance of contamination. The US Food and Drug Administration peak out that some *Salmonella* outbreaks have been traced to contaminants in spices [47]. Unhygienic kitchen surfaces that lack of hand washing measures all through food preparation and be deficient in hand washing after going to the bathroom or changing a baby's diapers are extensive path for contamination and infection. Domestic reptiles or amphibians may spread *Salmonella* in their gut without becoming ill. They throw the bacteria in their droppings, which can `quickly extend through their skin and then everything they come up to contact with, as well as cages, toys, clothes, and furniture or household surfaces. *Salmonella* bacteria exist in the intestines of people, animals and birds. A large number of peoples are infected with *Salmonella* by eating foods that have been contaminated by feces.

POSSIBLE REASONS FOR SALMONELLOSIS IN POULTRY SECTOR OF BANGLADESH

From FAO statement, production of poultry meat and eggs in Bangladesh is growing rapidly over the last 15 years. Poultry meat production has increased from 660 tons in 1990 to 6.2 million metric tons in 2016 and egg production has increased 11,912.4 million over the same period [48] Growth rate of chicken production in Bangladesh was 5.3% per year and consumption of broiler meat and eggs could grow by 95% and 78% respectively, in the period of 2020 [49]. This growth will be being driven by the increase in the market demand. As poultry is not an internationally marketed commercial product in Bangladesh, very few controlled vertical production systems have been established. Most poultry is sold in live bird markets and about 90% of the rural families maintain small numbers of chickens [50].

Their present two laws related to slaughter and meat, the Animal Slaughter and Meat Act (1957) and the Municipal Corporation Ordinance (1983). These two laws has cleared animal categories allowed for slaughtering, provisions for meatless days, etc. These had not set out minimum procedures for slaughter stated Svendsen [51]. Again these did not cover guidelines for pre-slaughter and post-slaughter inspection. The Animal Disease Act and the Animal Products Quarantine Act were approved by the country's parliament in 2005.

One factor that responsible for the slow accomplishment of international regulatory tools such as HACCP in the poultry sector in Bangladesh is tremendously high start-up costs [52]. A 10% occurrence of *Salmonella* in commercial poultry farms in Bangladesh from 1200 farms were tested by Hoque et al. [53]. *Salmonella* is endemic throughout the country. With regard to chemical risk factors, the exploit of antibiotics is extensive all over the poultry sector. Antibiotics are used for therapeutic and as growth promoters in feed [53].

In spite of the efforts made by the government, there are major deficiencies with respect to food security in poultry production of Bangladesh. Consumer consciousness of foodborne illnesses is quite effortless. Purchaser organizations present in developed countries exercise pressure on producers to apply food-safety actions are weak or non-existent in Bangladesh. This hampers to accomplishment of existing policies. There is also lack of alertness of consumer rights and food-safety risks. Another problem is related to financial. Even if awareness is greater, financial limitations influence consumers' choices and promote the consumption of poorer quality products [54].Regardless of efforts to begin consumer-protection legislation, enforcement remains poor. In addition, the vertical links from the government to the villages are quite weak; may lack the information or the incentives essential to apply the food-safety regulations passed by parliament also responsible for Salmonellosis in Bangladesh.

CONTROL OF SALMONELLOSIS

There is very little vaccine to prevent Salmonellosis [24]. Foods of animal source may be infected with *Salmonella*; for this people should not take raw or undercooked eggs, poultry, or meat. Chick and meat, plus hamburgers, should be well-cooked, not pink in the middle. Poultry products should be thoroughly washed.

Cross-contamination of foods must be avoided. Fresh meats should bed is connected from produce cooked foods and ready-to-eat foods. All kinds of utensils must be washed thoroughly after touching raw foods. Hand should be washed prior to handling food and handling

diverse food items. Peoples having salmonellosis should not prepare food or discharge water for others until their disease has resolved [55]. Health departments need a stool for the test of *Salmonella* infection showing that restaurant workers are no longer carrying the *Salmonella* germs before they return to work. Public should wash their hands following contact with animal feces. As reptiles are mainly liable to have *Salmonella* can contaminate their skin, everybody should instantly wash their hands after handling reptiles. Reptiles are not appropriate pets for small children and should not be in the same house as a baby [56]. *Salmonella* present in the intestines of chicks and ducklings contaminates their environment and the entire surface of the animal [55]. Kids can be attacked to the bacteria basically by holding, cuddling, or kissing the birds. Kids should not touch baby chicks or other young birds. Everybody should instantly wash their hands after touching birds, baby chicks and ducklings, or their environment.

Food-safety regulations and risk analysis are other way to control salmonellosis. In order to arrange food safety strategies for countries or regions, some basic frameworks have been designed by international regulators. The modern approach is to use risk analysis tools. According to Adams and Moss [57], such tools include the following steps:

• Identification of the hazards (the risk factors).

• Exposure assessment–estimating the likely intake of the agents.

• Hazard categorization–quantitative and qualitative analysis of the risk factors.

• Risk characterization–estimating the probability and severity of the possible food-borne illness.

According to FAO [58], this approach in a large extent has been successfully implemented in the developed countries food production sector. But the proper implementation of risk analysis tools requires some fundamental components. These may include efficient public health institutions, sufficient laboratory facilities, skilled human resources and well-designed infrastructure for Food-safety concerns in the poultry sector of developing countries. Many countries are weak with respect to one or more of these mechanisms. A careful analysis of the country or region should be implemented before taking into consideration the application of such tools.

Developed world markets follow international sets of policy. The major group of actors in the international rule-setting forum are the FAO/WHO Codex Alimentations Commission with its Hazard Analysis and Critical Control Point guidelines. The World Organization for Animal Health (OIE) with its Terrestrial Animal Health Code and the World Trade Organization (WTO) which sets the sanitary and phytosanitary framework for international trade [59].These sets of rules and practices are widely accepted in developed countries and international markets. As well as the main rule setters mentioned above, there are several other international and regional bodies, for example, the International Atomic Energy Agency (IAEA) [60]. European Food Safety Authority (EFSA) and the African Regional Standardization Organization (ARSO) which sets regulation concerning irradiation of food and feed. Although having so many regulatory authority 90% of the world's livestock trade is within domestic markets. Several environmental factors like air, dirty litter and unhygienic facilities and vectors, such as insects, humans and rodents are also liable for *Salmonella* infection in poultry farm. There are numerous methods of identification of *Salmonella* in field level such as an indirect enzyme linked immune sorbent assay (ELISA), double ELISA, rapid plate agglutination and whole blood agglutination test [63]. Rapid plate agglutination (RPA) test is frequently used in field condition to identify *Salmonella* as it can be performed simply and need less time as well as economic [62].

RECOMMENDATIONS

Eggs associated Salmonellosis is an important public health problem in the world. We have to consider some of the point that eggs offered for sale must be free of faeces, dirt and stains. Premises and equipment for handling and storage of eggs must be maintained in a sanitized state fit for the production of food for human consumption. Egg farms must be regularly visited by field inspectors to monitor bird health by recording feed and water intake, rate of lay, egg quality, bird's behavior and appearance. Continuous monitoring and control methodologies, which should be applied in poultry farms for the control of spread and eradication of this pathogen, where possible, are strongly recommended. Efforts in critical control point programs of food production are needed to lessen the incidence of *Salmonella* in food. Consumer's awareness efforts would protect public health from foodborne Salmonellosis.

CONCLUSION

It can be concluded that the balanced use of antibiotics needs to be adopted in commercial poultry farming system to prevent the emergence of drug-resistance *Salmonella* to protect the public health consequences [3].

In addition, salmonellosis is affected by age, location, season, processing, and many other factors in Poultry (Fig. 4). Poultry rearing can play a vital role for income generation and poverty reduction particularly for the distressed women, unemployed youths in Bangladesh by means of self-employment. For this purpose, a model of semi scavenging poultry rearing system known as MBPF has been developed under the Poultry Management Technology Improvement Projects (PMTIP), Partnership Livestock Development Project (PLDP) and Small Holder Livestock Development Project (SLDP-2). In model farming, very good breed of chickens need to be reared instead of indigenous local chicken because of their high productivity and increased resistant to diseases [61]. Numerous research works has already made on the prevalence of *Salmonella* contamination by the previous author in different districts of Bangladesh. They mainly focused on isolation, identification and serological tests [3, 28, 39, and 40]. However, more research on the seroprevalence of *Salmonella* infection covering extensive geographical areas of Bangladesh is vital to design effective control program. This review emphasized on the need to execute practical measures of hygienic practices, surveillance programs for laying hen flocks should be optimized. The use of Hazard Analysis and Critical Control Point (HACCP) in the preparation and processing of foods with the aim of reducing *Salmonella* contamination of eggs in trade and to reduce the risk of human infection.

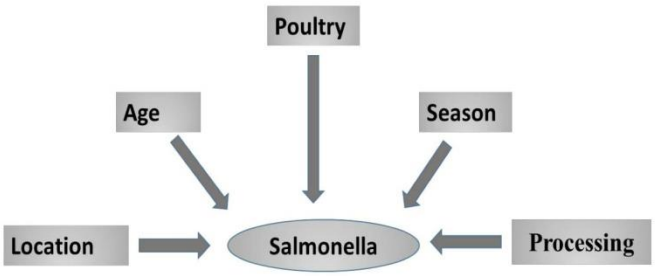

Figure 4. Factors affecting Salmonellosis in Bangladesh.

AUTHOR CONTRIBUTION

Rasha Binte Mohiuddin and Md. Najmol Hoque were involved in collecting data, preparing the report according the format, drafting the article. Other authors were equally involved in designing the draft article, rechecking the reports authorization.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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