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Public Health Importance of Bovine Salmonellosis in Ethiopia: A Review

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Abstract: Salmonellosis is the zoonotic disease caused by pathogenic *Salmonella* Species. The feco-oral route is the most important mode of transmission of Salmonellosis in animals. It is an important worldwide public health challenge causing substantial morbidity and has a significant economic loss. Human salmonellosis is mainly foodborne which is transmitted through consumption of contaminated food of animal origin which includes meat, milk, poultry meat and eggs. Some studies conducted in Ethiopia on prevalence of *Salmonella* provided that there were different levels of prevalence of disease in different parts of the country. Epidemiological pattern, prevalence and incidences of disease differ greatly between geographical areas. This is affected by pathogens themselves, industrialization, urbanization and change of lifestyles, knowledge, belief and practices of food handlers and consumers, demographic changes, international travel and migration, international trade in food, animal feed and poverty and lack of safe food preparation facilities. Having animals and raw products, it is not possible to be free from zoonotic agents like *Salmonella;* however the occurrences can be minimized by applying high standard of hygiene in all steps of food production. Some topics highlighted in this paper are the epidemiology; mode of transmission; treatment and control; public health importance; conclusion and recommendations.

Key words: Epidemiology · Foodborne · *Salmonella* Species · Zoonosis

INTRODUCTION

Salmonella causes gastroenteritis and typhoid fever and is one of the major foodborne pathogens of significant public health concern in both industrialized as well as developing countries even though the incidences seem to vary [1, 2]. Salmonellosis is a common intestinal illness manifested clinically in animals [3] and humans [4] as acute and chronic enteritis, an acute septicemic disease or as subclinical infections [5]. It is characterized clinically by one or more of the three major syndromes; septicemia, acute and chronic enteritis [6].

Salmonella are often of concern due to the disease of cattle and the potential to infect human that come in contact with cattle or consume dairy and meat products. *Salmonella* are common in cattle. Meat processing and packaging at the whole sale or retail level contribute to higher levels of contamination in minced beef product compared to beef carcass. The presences of even small number of *Salmonella* in carcass and edible offal may lead to heavy contamination of minced meat. Raw meat particularly, minced meat has a very high total count of microorganisms of which *Salmonella* are likely to present large in number [7].

The epidemiology of foodborne problems like Salmonellosis is complex and expected to vary with change in the pathogens themselves, industrialization, urbanization and change of life styles and practice of food handlers and consumers, demographic changes (Increased susceptible population), international travel and migration, international trade in food, animal feed and in animals and poverty and lack of safe food preparation facilities [8]. Foodborne illness including Salmonellosis are widespread and have an impact on communities in both developing and developed world [9]. In industrialized countries, the incidences of salmonellosis are on the rise due to the emergence and increase of *S. Enteritidis* and *S. Typhimurium* DT 104 [10, 11]. There are pandemics of *S. Enteritidis* and *Typhimurium* DT 104 which resulted in enacting regulations in many countries to control the prevalence of salmonellosis in farm animals in order to prevent foodborne infection [11].

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The clinically normal carrier animal is a serious problem in all host species. Foods of animal origin, particularly meat, poultry and in some instances, unpasteurized egg products are considered to be the primary sources of human Salmonellosis [5, 11, 12]. Most of these food products, for example; beef, mutton and poultry, contaminated during slaughter and processing, from the gut contents of healthy excreting animals. In the same way, all food that is produced or processed in a contaminated environment may become contaminated with *Salmonella* and be responsible for outbreaks or separate cases of disease as a result of faults in transport, storage, or preparation [13].

Earlier investigations made by different researchers in Ethiopia have demonstrated the presence of *Salmonella* in apparently healthy slaughtered cattle [14, 15] minced beef [14, 16] poultry farms [17] poultry meat and offal [15, 18] selected food items [19] farm livestock, raw "Kitfo" samples [20] and samples from butchers' shop [21] and human beings [22]. Therefore, the objectives of this paper were to review the public health and economic importance of bovine salmonellosis and to give general recommendations based on the shortcomings in Ethiopia.

Epidemiology of Salmonellosis: Although *Salmonella* are primarily intestinal bacteria, they are widespread in the environment and commonly found in farm effluents, human sewage and in any material subject to fecal contamination. Salmonellosis has been recognized in all countries but appears to be most prevalent in areas of intensive animal husbandry, especially poultry and swine production [11]. The epidemiology of *Salmonella* is complex which often makes control of disease difficult. Epidemiological pattern of prevalence of infection and incidences of disease differ greatly between geographical area depending on climate, population density, land use farming practice, food harvesting and processing technologies and consumer habits. In addition, the biology of serovar differs so widely that *Salmonella* infection or *Salmonella* contamination are inevitably complex [16]. Sibhat *et al.* [23] found the serovars Newport, Anatum and Eastbourne to be the most prevalent in Ethiopia.

Public Health Importance: All strains of *Salmonella* are known to infect man and many other animal species [24]. Salmonellosis is an important global public health problem causing substantial morbidity and thus also has a significant economic impact [25]. In spite of the improvement in hygiene, food processing, education of food handlers and information to the consumers, foodborne diseases still dominate as the most important public health problem in most countries [26].

Source of Infection: Infection and epidemics are usually traceable to various food products derived from meat, eggs, milk and poultry. Other means of infection are derive from food and water contaminated with wild living birds and rodent feces, from infected food handlers and from contaminated equipment and utensils. A more common hazard arises through cross contamination from raw to cooked meat or other foods and subsequent time temperature abuse [7]. The higher the number of contacts, the higher will be the risk of direct transmission. Epidemiological surveillance of animals, including birds, is of the utmost importance, since the source of the large majority of non-typhoid Salmonellosis cases is food of animal origin [5].

Because *Salmonella* are facultative intracellular organisms that survive in the phagocyte of some macrophages, they can evade the bactericidal effects of antibody and complement. Thus, persistence of infection in animals and in the environment is an important epidemiological feature of Salmonellosis [3]. Although *Salmonella* may survive for long periods in the environment [27] it is the carrier state that provides the major source of infection for animals and humans.

Transportation of animals, overcrowding and administration of corticosteroids, parturition and concurrent viral and protozoan infections have all been shown to increase susceptibility of animals to disease [28]. Intensification of husbandry in all species is recognized as a factor contributing significantly to an increase in the new infection rate [3]. The carrier domestic (Including poultry) and wild animals, turtles and other pets shed *Salmonella*. Human patients and subclinical carriers may also shed organisms. Other sources are whole eggs; especially duck eggs, egg products, meat and meat products, poultry and fertilizers and animal feeds prepared from bones, fish meals and meat. Insects, particularly flies, may have some role as mechanical vectors in very contaminated environments. In developing countries, the source of infection is mainly the contaminated environment and water sources where animals are crowd together. Salmonellosis is an important zoonosis and, although human-to-human transmission does occur, especially in pediatric wards, nurseries and nursing homes, animals and their products constitute the most important source of the organism for humans [29].

Occurrence in Man: Human salmonellosis is generally foodborne and is contracted through consumption of contaminated food of animal origin such as meat, milk, poultry and eggs. However, fruits and vegetables such as lettuce, tomatoes, cilantro, alfalfa-sprouts and almonds have also been implicated in recent out-break. Acute gastroenteritis is usually acquired from consumption of food which may be directly or indirectly contaminated with *Salmonella.* A wide variety of animal species have been shown to be capable of harboring the organisms and in the developed world; turkey, chicken, swine and cattle are found to be infected carriers in the studies conducted in the abattoirs. Person to person spread also may occur in hospitals, nursing homes, mental institution in which large number of outbreak has occurred [30]. Direct or indirect contact with animals colonized with *Salmonella* is another source of infection, including contact during visits to petting zoos and farms [31].

Fecal oral route and vehicle born infection may result from ingestion of food or water that have been contaminated with human or animal feces or from direct exposure to animals or their waste. The commonly recognized vehicle of transmission includes inadequate cooked or raw meat, unpasteurized milk or milk product, contaminated and inadequately treated drinking water [24]. Contamination of milk may occur by a variety of routes. Animal may occasionally, excrete the organisms in milk during the febrile stage of the disease or more likely infected feces from either a clinically infected cow or healthy carrier may contaminate the milk during the milking process. Indirect contamination has also been described when cattle have become contaminated with *Salmonella.* Contamination of food also may occur directly from *Salmonella* infected food handlers or indirectly from sewage polluted water [32].

Salmonellosis occurs both in sporadic cases and outbreaks affecting a family or several hundreds or thousands of people in a population. The disease in human occurs in a wide variety of forms presenting a broad clinical spectrum. In countries with a reporting system, the number of outbreaks has increased considerably in recent years; this increase is in part real and in part due to better reporting [33]. In a large number of cases salmonellosis in man is recognized as a type of food poisoning, the severity of which can vary from mild diarrhea to acute gastroenteritis. Gastrointestinal salmonellosis and its serious sequelae are linked to a wide variety of illnesses and therapies that affect the body's multiple defenses against enteric and intracellular pathogens [4]. The disease may also occur as a focal infection in any organ of the body, or as a systemic febrile infection [24].

Prevalence of Salmonellosis in Ethiopia: The study conducted to determine the prevalence and antimicrobial resistance pattern of *Salmonella* isolates from lactating cows and in contact humans in dairy farms of Addis Ababa determined the overall prevalence of 10.7% of cows and 13.6% of the humans shaded *Salmonella* [34]. Lactating cows could be potential sources of *Salmonella* infection for individuals' working in dairy farms and for the community at large. The prevalence of *Salmonella* among individuals working in dairy farms of Addis Ababa was 13.63% [34]. The result is higher than a study conducted by Alemayehu *et al.* [35] and Zewdu and Cornelius [36] who reported a prevalence of 6 and 7.6%, respectively. Basic hygiene practices and the implementation of scientific based management strategies can efficiently mitigate the risks associated with animal contacts. However, the general public is frequently unaware of the specific disease risks involved and high-risk behaviors are common. The disease can be also controlled by vaccination of cattle [37]. According to a study conducted to overview the Microbiological Quality of Milk Produced in Urban and Peri-Urban Farms in Central Ethiopia and its Public Health Impact to help implement quality standards and determine the public health significance of milk borne pathogens, a pilot study was performed to establish baseline data on the microbiological quality of milk throughout central Ethiopia. Fresh bovine milk samples and combined bulk tanks in Selale, Asela, Akaki and Debre Zeit were examined and the results showed 0% prevalence of *Salmonella* in both pooled and bulk tank samples [38].

The Zoonotic Nature of the Disease: Salmonellosis is perhaps the most widespread zoonosis in the world. The non-typhoid *Salmonella* Serovars differ in their degree of human pathogenicity; *S. Pullorum* and *S. Gallinarum* being among the least pathogenic and *S. Cholerae suis, S. Dublin* and *S. Enteritidis* are being the most pathogenic [39] and often invasive with sustained bacteremia [40]. *Salmonella* of animal origin cause an intestinal infection in man characterized by a 6 to 72 hour incubation period after ingestion of the implicated food and sudden onset of fever, myalgia, headache and malaise. The main symptoms consist of diarrhea, vomiting, abdominal pain and nausea [5]. Although salmonellosis

may occur in persons of all ages, incidence is much higher among children and the elderly [41]. Dehydration can be serious [5].

In the developing world, HIV infection is a prominent risk factor for non typhoidal salmonellosis and bacteremia [4]. Salmonellosis usually heals without complications and the main treatment recommended is rehydration and electrolyte replacement [24]. Although rare, there may also be different localizations such as infections of joints, lungs, pleura, endocardium, abdominal organs, central nervous system and bone, urinary and genital tracts [40]. The average mortality rate is 4.1%, varying from 5.8% during the first year of life, to 2% between the first and 50th year and 15% in persons over 50. Among the different serotypes of *Salmonella, S. cholerae* Suis has been reported to produce the highest mortality (21%) [39].

Economic Significance: Salmonellosis, a common human intestinal disorder primarily caused by *Salmonella* contaminated meat and poultry, is estimated to cost nations billions of dollars annually there by draining funds that could have been used for development [3]. Financial costs are not only associated with investigation, treatment and prevention of human illness but may affect the whole chain of food production. Thus, the costs of salmonellosis, as with other foodborne illness, fall into both the public and private sectors and may be surprising, both in terms of the level of costs incurred and the variety of areas affected. In the public sector, resources may be diverted from preventative activities into the treatment of patients and investigation of the source of infection [42]. The number of deaths from foodborne disease like salmonellosis is likely to be underestimated [43] as most estimate of mortality are short term and do not take into account coexisting illnesses.

Salmonella infection has substantial financial and social impacts. Medical costs and lost production are examples of tangible costs which are easily measured in monetary terms, while costs such as loss of leisure and pain and discomfort are intangible costs difficult to measure. Costs to society include costs of illness which fall directly on the ill person's and their immediate family; costs to the national economy which relate to sickness absence from work; and cost to producers, manufacturer or retailer when food products are implicated in food poisoning outbreak [42]. Salmonellosis is a significant cause of economic loss in farm animals because of the costs of clinical disease that include deaths in a small proportion of cases, decreased milk and meat production, reduced value of contaminated products, diagnosis and treatment of clinical cases, diagnostic laboratory costs, the costs of cleaning and disinfections and the costs of control and prevention [3].

Treatment and Control

Treatment: In man antibiotics are not indicated in *Salmonella* gastroenteritis, except in very young and those over 60 and to individuals with severe invasive infection [40, 44] since the disease is brief and limited to the gastrointestinal tract. In addition, the unnecessary use of antibiotics prolongs *Salmonella's* creation, promotes the incidence of the carrier state and favors the acquisition of resistance by the infecting strain [4, 31]. Treatment of the systemic form includes nursing care and appropriate antimicrobial therapy as determined by retrospectively acquired susceptibility data. Treatment options may be compromised due to acquisition of resistance (R) plasmids encoding resistance to multiple antibiotics [45].

Treatment of non-typhoidal *Salmonella* infection is different from typhoidal infection. In treatment of non-typhoidal *Salmonella* infection antibiotics should not be used routinely, as used in typhoid. Antibiotic should be only used if required as most infection with non- typhoidal *Salmonella* is self-limiting type and duration of diarrhea and fever are not much affected by use of antibiotics. The main treatment should be aimed at correcting dehydration that may arise due to prolonged diarrhea by fluid and electrolyte replacement [46].

Following the introduction of fluoroquinolones a number of clinicians have advocated their use for treatment of only on enteric fever but also of *Salmonella* gastroenteritis because of their efficacy in reducing the duration of illness and of *Salmonella* shedding. In case of patient with bacteremia and other complications antimicrobials are used. Like-wise the treatment of enteric fever necessitates the use of antimicrobial drugs with chloramphenicol, ampicillin, amoxicillin, trimethoprim-sulfamethoxazole and newer fluoroquinoazoles being drug of choice against sensitive *Salmonella.* Proper management of fluid and electrolyte balance is important in all patients with *Salmonella* gastroenteritis but is crucial in young children and elder individuals [30].

In animals supportive treatment with intravenous fluid is necessary for patients that have anorexia, depression, significant dehydration. Oral fluid and electrolyte may be somewhat helpful and much cheaper

than IV fluid for cattle demand to be mildly or moderately dehydrated. Cattle that are willing to drink can have specific electrolyte (NaCl, KCl) added to drinking water to help correcting electrolyte [47]. The implementation of broad prophylactic strategies that are efficacious for all *Salmonella* may be required in order to overcome the diversity of *Salmonella* serovars present on farms and the potential for different serovars to possess different virulence factors [48].

Control: The control of *Salmonella* in meat animals and derived products is a most challenging task because of the complexity and interdependence of various aspects of animal husbandry, slaughtering and food processing. Because of the complexity of *Salmonella* virulence factors, little progress has been made in converting the available knowledge in to therapeutics. Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), Hazard Analysis Critical Control Point (HACCP), system appropriate food handling and adequate water treatment remain the best preventive measures for most *Salmonella* infection, although the typhoid vaccines are effective against *S. typhi* in humans vaccines for several other serovars have shown promise in food animals [49, 50].

In order to record marked reductions in the prevalence of *Salmonella* in food coordinated control efforts at various critical points from the "Farm'' to the "Table" is essential. Additionally, comprehensive educational programs for the consumer and food handler, both in commercial establishments and in the home, about correct cooking and refrigeration practices for foods of animal origin and about personal and environmental hygiene is of paramount importance [50]. Veterinary meat and poultry inspection and supervision of milk pasteurization and egg production are important for consumer protection [5]. Adequate nutrition and hygiene prior to and during transport and within the abattoir could be an important intervention to prevent spread of salmonellosis [11].

Antimicrobial Resistance: Studies show that antimicrobial resistant *Salmonella* are increasing due to the use of antimicrobial agents in food animals, which are subsequently transmitted to humans' usually through the food supply [51, 52]. Globally, the three main causes of antimicrobial resistance have been identified as use of antimicrobial agents in agriculture, over-prescribing by physicians and misuse by patients [50]. *Salmonella Typhimurium* DT 104 has a broad host reservoir and is usually resistant to five antibiotics (Ampicillin, chloramphenicol, streptomycin, sulphonamides and tetracycline) and can be resistant to others (e.g., fluoroquinolones) [50, 53]. The ultimate outcome will be to prolong the efficacy of existing and new antimicrobial agents which are desperately needed to control both human and animal diseases and to minimize the spread of resistant zoonotic pathogens to humans [9]. The choice of the drug for treatment of salmonellosis should always be based on sensitivity testing of the causative strain. Many farmers are uneducated and live in very close contact with their animals, often under poor hygienic conditions, thereby increasing the likelihood of food borne zoonosis. During the past decade, bacteria that cause human disease have developed resistance to many of the antibiotics commonly used for treatment [54]. The incidence of zoonotic foodborne *Salmonella* infection has increased in most industrialized countries [51]. In recent years, testing of *Salmonella* isolates has shown that an increasing proportion of isolates are resistant to several antimicrobial agents both in developing and developed countries. The strains of S. *Typhimurium* known as definitive phage type 104 (DT 104) have become a worldwide health problem causing illness in humans and animals. It is usually resistant to five drugs: ampicillin, chloramphenicol, streptomycin, sulfonamides and tetracycline [9, 4, 52]. In the developing world, nosocomial and community acquired multidrug-resistant salmonellosis have been recurrent problems. The origins of resistance in the developing world are unknown [55].

Resistance in *Salmonella* limits the therapeutic options available to veterinarians' and physicians in the treatment of certain cases of salmonellosis [54]. Drug resistance in *Salmonella* increases the frequency and severity of infection with this pathogen, limits treatment options and raise health care costs. These effects may be related to enhance shedding and augmented virulence of resistant strains, increased rates of transmission of this strain and the ineffectiveness of initial regimens of antimicrobial therapy against such strains [56]. Inappropriate antibiotic treatment of a septicemic patient infected with a resistant *Salmonella* strain could lead to a fatal outcome if the therapeutic drug administered up on hospitalization subsequently proved to be identical to the resistance phenotype [57]. In the countries of the developing world, which are responsible for about 25% of world meat production, policies regulating veterinary use of antibiotics are poorly

developed or absent [54]. In developing countries, the principal cause of the emergence of multi-resistant *Salmonella* strains may be self-medication, made possible by the public's easy access to antibiotics without prescription [5].

CONCLUSIONS AND RECOMMENDATIONS

Human salmonellosis is generally foodborne and is contracted through consumption of contaminated food of animal origin such as meat, milk, poultry meat and eggs. Salmonellosis is a common intestinal illness caused by numerous *Salmonella* serovars. Due to the different levels of prevalence of disease in both animals and human in the country, higher attention and collaboration needed from veterinary and public health professionals for control and prevention. Finally, implementing basic and applied research to the agent that cause zoonotic salmonellosis will be a crucial point for new approaches to prevent and control the disease. Based on the above conclusion the following recommendations are forwarded: Milk and milk products should be pasteurized before drinking. Meat should be thoroughly cooked before eating. Establishment of HACCP should be applied to food and food products. Setting import standards for food and food items should be done. Encouraging judicious use of antimicrobial drugs in veterinary and public sectors is a very important issue. Collaboration between government, professional organizations and interest groups on control and prevention of the disease is beneficial.

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