



## Current Trend on the Economic and Public Health Significance of Salmonellosis in Iraq

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**Abstract** | Salmonellosis is reported as one of the main cause of diarrhoeal diseases globally. The disease is also associated with enteric fever, including typhoid which is a potentially fatal systemic illness bedeviling many developing countries. The disease is estimated to affect nearly 17 million people with over 150,000 deaths occurring annually. Salmonellosis is also beginning to emerge as a foodborne infection characterized by significant economic and public health hazard with global ramifications. High prevalence of the disease is directly related to poor sanitation and hygiene, consumption and use of unsafe water, overcrowding and social unrest. A significant number of Iraqis are affected annually with a death rate of 10-20 %, mainly resulting from limited access to fresh water and improper sewage disposal into the river bodies. This review provides an overview of *Salmonella* infection in human and animals, with emphasis on the economic and public health burden of the disease in Iraq.

**Keywords** | Salmonellosis, Foodborne pathogen, Iraq, Diarrhoea, Economic importance, Prevalence

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## INTRODUCTION

Salmonellosis caused by either *Salmonella enterica* or *S. bongori* (Popoff, Bockemühl, & Gheesling, 2004; WHO, 2018), is an important zoonotic infection that is common to humans and a wide range of animals (Herikstad, Motarjemi, & Tauxe, 2002). The pathogen comprises a broad pathogenic serovars capable of causing varying levels of illnesses in humans and animals depending on the infecting serotype, age as well as the immune status of the patient (Ala'din, 2004). *Salmonella* infections is considered one of the major causes of diarrhoeal diseases globally and although most cases are mild and occasionally self-resolving, life-threatening clinical illness is common (Ala'din, 2004). Two of the most common clinical spectrum of the disease are gastroenteritis and typhoid fever. The disease is

also considered an important foodborne illness with significant public health ramification (Fluit, 2005). Salmonellosis is considered the most frequent foodborne zoonosis in more developed and less developed countries. It is also associated with many other disease syndromes; including septicaemia, acute and chronic enteritis (Sherrill, 2018). The importance of salmonellosis as a human disease is continuously gaining relevance due to rapid changes in the epidemiological trends and the emergence of strains which are resistant to the commonly used chemotherapeutic agents (Kemal, 2014; Salihu, et al., 2015). The increase in the proportion of outbreaks from consumption of meat and meat products, as well as fresh vegetables has resulted in a proportionately similar increase in the number of human incidents. Food is the most important vehicle that transmits the microorganisms to human (Varnam, 1991),

with poultry and poultry products being the most common source of *Salmonellae* as well as fresh fruits and vegetables, especially when they are consumed after improper processing (Bailey & Cosby, 2003; Kimura et al., 2004). The usual source of contamination to these edible products is either the poultry themselves, or following cross-contamination with faeces from reservoirs, as well as water, instruments and workers' hands during the animal handling and slaughtering process. Meanwhile, the main source of contamination of farm produce is by the application of manure from possibly infected or reservoir animals or humans.

### GLOBAL BURDEN OF SALMONELLOSIS

The emergence of foodborne pathogens as an important public health hazard globally have been recognized in many countries in the last decade (Herikstad et al., 2002). *Salmonella* species are often incriminated as the primary causative agent of gastroenteritis globally. Similarly, *Salmonella* Typhi and Paratyphi are thought to be the major cause of enteric fever in humans. The global health burden posed by typhoid and paratyphoid fever is estimated to be more than twenty million cases annually, with over 200,000 deaths (Crump et al., 2004; Crump & Mintz, 2010). Like the enteric infection, a significant fraction of the burden is witnessed among poorly immune young children and adults suffering from debilitating illnesses. Despite the public health and economic importance of this zoonotic disease and its widespread distribution globally, the actual human health impact of the disease has not been comprehensively ascertained (Majowicz et al., 2010). Gastroenteritis is associated with morbidity and mortality, and most of the human related enteric illnesses are seen in children, the elderly and individuals suffering from immune suppressing illnesses (Kirk et al., 2015). The burden of this foodborne disease is substantial; as almost 1 in every 10 individuals acquire the infection, and in severe cases, about 33 million individuals, mostly young children and the elderly die annually (WHO, 2018). Salmonellosis is also said to be among the leading cause of diarrhoeal diseases, particularly among children living under poor hygienic conditions in most resource poor countries. Studies in developing countries indicated that incidence of diarrhoeal disease was reported to be in excess of 115 episodes per 1000 child annually (von Seidlein et al., 2006). Based on this data, it can be reasonably predicted that about 2.8 billion cases of diarrhoeal illness occur each year worldwide (Scallan et al., 2011). Although, the estimated total number of cases reported is often conflicting when compared to reports from other regions. The high number of cases recorded is as a result of mass production and distribution of food which aids the rapid dissemination of the pathogens. This is in addition to the emergence of multidrug resistant strains which poses new challenges in the prevention and control efforts. However, implementation and enforcement of safe food production and processing on a global scale will help

improve the present food safety concern and reduce the burden of salmonellosis.

### PUBLIC HEALTH SIGNIFICANCE

Prior to the war in 1990, the general public health indices and epidemiological situation in Iraq was at par with many developed countries where the health care delivery system is functioning optimally and arguably the best in the Middle East region. Unfortunately, within a decade, the situation has dramatically changed and become extremely dire. For instance, the World Health Organization (WHO) and United Nations Children's Fund (UNICEF) has estimated that for over 10 thousand population only 30 children suffering from diarrhoeal diseases, and 55 with respiratory illnesses as well as other child-related ailments had an access to healthcare institutions (UNICEF, 2001). Similarly, it is estimated that nearly a quarter of children in Iraq suffer from chronic malnutrition while the number of death ranked among the highest in the world (UNICEF, 2001). The high morbidity and mortality observed among the Iraqi population is attributed to the dilapidation of health care infrastructure, infectious disease as well as other gastrointestinal tract infections, which accounts for about 70% of deaths among young children (UNICEF, 2001).

The number of outbreaks and hospitalizations as a result of infection with *Salmonella* has increased alarmingly in recent years (Betsy Booren, 2012). It is estimated that out of 9.4 million foodborne illnesses, *Salmonella* is projected to be responsible for about 10% of the illnesses, resulting in 19,336 hospitalizations and 378 deaths (Majowicz et al., 2010). *Salmonella* is projected to contribute 11% of all known foodborne illnesses (Majowicz et al., 2010) with death amounting to 28% (Majowicz et al., 2010). One of the important source of *Salmonella* infection is the consumption of meat, egg or feeds of poultry origin. Foodborne diseases constitute a public health hazard which tends to increase worldwide, particularly in individuals that patronize public eateries (Noori & Alwan, 2016). Beef and chicken meat contaminated with fecal organisms represent an important food hygiene problem, especially when the contamination involves enteric pathogens like *Escherichia coli*, *Klebsiella*, *Proteus* as well as *Salmonella* species. In a recent study conducted by Noori and Alwan (Noori & Alwan, 2016) to determine the prevalence of some bacterial pathogens of public health significance among the local and imported broiler meat in local markets of Baghdad city, *Salmonella* represents 39% out of the 85% of the bacterial isolates detected. In addition, the *Salmonella* isolates were equally found to be multidrug resistant. The result of the above-mentioned study emphasizes the notion that poultry meat represents a very important source of infection with *Salmonella*. In addition, it also indicates the potential role of market contamination as a significant risk factor in the spread of the bacteria among households.

More importantly, is the fact that the species isolated are resistant to the commonly used antibiotics and hence constitutes a serious health hazard to consumers (Noori & Alwan, 2016; Saikia & Joshi, 2010). The isolation of multidrug resistant *Salmonella* may indicate the source of poisoning from poultry meat that has resulted in increased hospitalizations as well as its associated economic repercussions (Ezekiel et al., 2011). Widespread distribution of drug-resistant salmonellae and complications associated with the treatment of infections constitute a serious threat to the public health (Su et al., 2004). In addition, the fact that most of the resistance exhibited by *Salmonella* serotypes is synonymous with the environment in which the organism flourishes. Immediate measures, comprising regulation and control of broad spectrum cephalosporins and fluoroquinolones in food animals and humans is paramount, especially in war torn Iraq. Moreover, detection of non-typhoidal *Salmonella* species in asymptomatic cats (carriers) has also been described as a potentially dangerous finding considering the close association of cats with human habitats. They could also provide a significant source of environmental contamination that may pose threat to public health (Mushgil et al., 2014). Thus, for effective control and prevention, efforts must be made to identify the potential source of the bacteria and strengthening of health care centers, especially in places like Iraq that have been devastated by long term conflict and war.

### ECONOMIC IMPORTANCE

Foodborne zoonoses including salmonellosis represent a serious challenge to the food industries and food security globally. Thus, efforts must be geared towards overcoming them as a means of enhancing public health and meeting needs of people for food supply. Sustainable *Salmonella* prevention can only however be achieved based on a systematic approach that needs to be holistic and comprehensive. Salmonellosis is associated with considerable social and economic burden resulting from financial costs upon the poultry industry and especially upon the infected individuals and their family as a result of hospitalization and death (Sockett & Roberts, 1991). While the cost incurred by the public-sector results from expenses from treatments and care of patients, as well as the environmental health services undertaken during investigation and management of the illness; the financial burden on the affected industries is borne from loss in productivity from both workers infected due to absentia and sponsorship of treatment (D'Aoust, 1994). Despite the economic importance of this disease, data on the actual economic burden is lacking. The situation in Iraq is even worse given loss of resources and displacement caused by war and civil unrest (WHO, 2014). Nonetheless, despite the economic burden exerted by salmonellosis, the disease is manageable under enabling environments. The situation is exacerbated by the migration of health care providers and doctors from these areas affected

by war to regions where the safety of their lives and that of their families is guaranteed, thereby creating a huge vacuum and compromising the ability to actually collect and ascertain the actual burden of the disease. The estimation of the costs as well as familiarization with the features and characteristics of the disease could be useful for an economic evaluation in order to ascertain the actual financial burden, which in turn will aid the development and implementation of preventive measures (Roberts, 2000). Several studies have demonstrated that *Salmonella* have been responsible for significant losses resulting from medication and labor absenteeism (EFSA, 2009). This finding is supported by the report of the USDA Economic Research Service (ERS) who estimated an annual medical costs of US\$ 9,087 for each hospitalized patient, with cases of death between, 960 to 1920 annually. Similar situation has been reported in the European Union where around € 4,000 has been spent on the treatment of patients (EFSA, 2009). In terms of livestock productivity, salmonellosis is a significant cause of economic loss due to death, cost of diagnosis and treatment, cost of cleaning and disinfection as well as cost of control and prevention (Kemal, 2014). In a related study conducted among buffaloes, *Salmonella anatum*, *S. muenchen* and *S. enteritidis* were found to be the most common isolates with 68.18%, 18.18% and 13.64% prevalence, respectively (Abdulrahman & Al-Hashimi, 2014). However, in a recent study conducted to determine the prevalence, risk factors, and antimicrobial resistance of salmonella species associated with gastroenteritis in Thi-Qar Governorate, Southeastern Iraq, 33 (10.3%) cases were stool culture-positive for non-typhoidal *Salmonella enterica* with Typhimurium (54%) being the majority. Multivariable logistic regression analysis showed that children from households supplied by pipe water has a higher chance of acquiring infection (4.7%) compared to those supplied with reverse osmosis treated water (Harb et al., 2017). This outcome may be as a result of breakage of water pipes passing through the sewage, thereby contaminating the drinking water (Harb et al., 2017).

### SOURCES OF SALMONELLA IN IRAQ

Many domestic animal species are known to carry different *Salmonella* spp and serotypes, thereby serving as potential source of contamination (Fufa et al., 2017). In this regard, many efforts have been made to detect and determine the prevailing *Salmonella* serotypes in Iraq. Both *S. Newport* and *S. typhimurium* have been isolated in faeces of sheep and cattle in the Duhok Abattoir, Kurdistan, Iraq (Zubair and Ibrahim, 2012; Martin et al., 2016). Similarly, *S. hato*, *S. typhimurium*, *S. hadar*, and *S. enteritidis* have been successfully isolated from faeces and gall bladder of goats in four central provinces of Iraq (Abdulrahman and Al-Hashimi, 2014). In addition to the aforementioned, domestic animals and birds have been found to harbor the bacteria in their intestine as a component of their normal

flora, thereby constituting a probable source of infection to humans (Chandra et al., 2006). Meats are often contaminated with this pathogen in most abattoirs during processing mostly from the faecal material of carrier animals, which often contaminate equipment, floors and personnel working in slaughter houses, particularly where hygiene is not observed. Hence, *Salmonella* spp are known to contaminate meat at any stage of production from abattoir to retail markets.

Carcasses of slaughtered animals and other meat products can also become contaminated during the processing and distribution stages (Hjartardóttir et al., 2002). Another important source of salmonellosis is the consumption of fruits or vegetable produced on farms where organic manure is used during their cultivation (Al-Nakhli et al., 1999). Moreover, this pathogen is known to survive and be transmitted by eating undercooked meat, or drinking water contaminated with faeces of infected animals or humans (Willey, 2015). Hence it is also considered a potential source of food poisoning in humans (Akoachere et al., 2009). The Center for Food Security and Public Health (CFSPH), reported that contaminated food of animal origin, especially meat products obtained from cattle and pigs, represent a major source of salmonella infection in humans (Rovid, 2005). The bacteria is responsible for a significant morbidity and mortality in both humans and susceptible animals (Akoachere et al., 2009). Callaway et al. (Callaway et al., 2008) reported that approximately 1.3 million people contracted food borne illnesses in the United States of America annually, which was attributed to salmonellosis. The widespread emergence of antimicrobial resistance is thought to be related to the unregulated use of antimicrobials in medical field and agricultural farming leading to the antibiotic gene cassettes dissemination (Ferber, 1998; Lindstedt et al., 2003). This has resulted in the development of drug-resistant strains of organisms in animals which invariably get transmitted to humans (Gallardo et al., 1999). Despite the fact that up to 2541 *Salmonella* serovars have been identified worldwide to cause outbreaks of food-borne illnesses, only a limited number are known to cause human infection (Popoff et al., 2004). Among the most prevalent strains in the Middle East region is the *S. enterica* Typhimurium, unfortunately it has equally been shown to demonstrate extensive antibiotic resistance (Frag et al., 2013). Moreover, non-typhoidal salmonella has been incriminated as the major cause of diarrhoea among children in both Baghdad and central Iraq (Al-Kubaisy et al., 2015); likewise in Mosul, northern Iraq up to 15% prevalence have been reported (Al-Rajab et al., 1988). In general, child mortality rate of 13% for boys and 12% for girls was reported in Iraq in 2003. Nevertheless, not much study has been reported in the south of Iraq except for the recent report by Harb et al. (Harb et al., 2017) in Thi-Qar, where 10.3% prevalence

was reported among children. *Salmonella typhimurium* is often used as a quality control indicator of food hygiene particularly among street vendors. Some of the common means by which foodborne pathogens are transmitted include the consumption of raw meat from sheep or beef or buffalo, and poultry products. Other important food items that could play a role in the transmission of the pathogen are milk, cheese, eggs, vegetables, and fruits (Martin et al., 2016). A number of outbreaks have been reported due to the consumption of food contaminated with this pathogen in addition to a large number of infections. A large number of foodborne pathogens and other microbial food safety indicators such as *Salmonella*, *Listeria monocytogenes*, and *Escherichia coli* have been found to be associated with poultry in Iraq (Kupradit et al., 2014). Given the importance of these health challenges and ease of transmission of the pathogen, it has become imperative to devise means by which the contamination by foodborne pathogens and other microbial food contamination are reduced and effectively monitored. The slab or boards where the carcasses are dressed and chopped are often left without proper washing and disinfection especially after every use. These surfaces are known to have the potentials of serving as a source of contamination to other carcasses and equipment as well as spread through flies or direct contact (Stevens et al., 2006). Ineffective protections of foods from dust and flies which occasionally harbor food borne pathogens are all important factors in the transmission of salmonellosis in addition to difficulties in sustaining required temperature for storage of food substances (Bryan et al., 1988). This may account for the continued contamination of raw foods with pathogenic bacteria including the role of food vendors especially during preparation and handling after cooking (Bryan et al., 1988; Zaghoul, 2014). This situation is common among some modern food service establishments who operate under poor hygienic condition (Scott & Gravani, 2005).

The safety precautions observed during production of poultry feed and the eventual quality is great significance in developed countries, hence, feed safety is seen as an essential requirement for all animals. Poorly processed animals can pose a health hazard and can also result in great economic losses due to the possibility of incurring death of a flock of birds (Nahid et al., 2010). Reports have confirmed the presence of harmful bacterial pathogens in poultry feed (Bryan and Doyle, 1995). This is because sourcing of raw materials for milling and the preparation and packaging of poultry feed results in exposure to many environmental contaminants including animal faeces that may contain hazardous pathogens that can end up infecting humans (Crump et al., 2002). Also, raw materials used in the production of poultry feed may become contaminated with pathogens during growing, harvesting, processing and storage of feed (Watkins et al., 1959). Contamination

with pathogenic microorganisms can also occur during processing, handling, mixing of ingredients and exposing the raw materials and finished products. Therefore, poultry diseases and death can occur as a result of consumption of contaminated feed (Rosemary et al., 2013). Although poultry is considered the most important reservoir of *Salmonella* globally, the organism is greatly distributed in domestic and wild livestock population including reptiles and wild birds. In recent years, significant increases in salmonellosis have been noted in large meat producing animals including buffalo. Buffalo production is a major component of the livestock industry in many Asian countries, as it serves as an important source of good quality meat, milk and farmyard manure (Singh et al., 2010). The buffalo is also recognized as the world second most important milk producing species (Bhatti et al., 2009). Salmonellosis is a bacterial disease with a rising prevalence in the cattle industry as well. It is most common in dairy calves but can also affect adult dairy cows and beef cattle. The disease has a serious economic impact on the cattle industry worldwide, usually resulting from the deaths of livestock, treatment costs, abortion and reduced production (Bryan & Doyle, 1995). The most common source of transmission is faecal contamination of feed and water from infected cattle to naïve cattle. Other modes of transmission are contaminated milk, contaminated processed feeds, and improperly cleaned calf-feeding equipment and the disease is more problematic because infected animals may shed the organism in their faeces without showing any clinical signs of disease (Martelli & Davies, 2012).

### INCIDENCE OF SALMONELLOSIS IN IRAQ

Iraq has experienced a long period of social unrest dating back to early 1990s and this has resulted in significant population displacement as well as deterioration of health care services (WHO, 2014). These conflicts have potentials to undermine meaningful socioeconomic development leading to the dilapidation of national infrastructure that ultimately end in a complex situation and humanitarian crisis (Webster, 2014). In many of the affected areas, the health infrastructure and access to health services have been disrupted as a result of the conflict. Notable among the affected and security-compromised governorates are Anbar, Diyala, Kirkuk, Ninewa and Salah-al Din whose health facilities have been damaged by bombing (WHO, 2014). Unfortunately, with the present population in Iraq projected to triple in the near future, this could spell mayhem in terms of public health risk and outbreaks of highly infectious diseases like salmonellosis which traditionally thrives under this kind of situations. Despite efforts to address health issues, the incidence of diarrheal disease has peaked as well as several outbreaks of typhoid fever and cholera recorded especially in southern Al-Basra province (Popoff et al., 2004). Some of the most common cause of diarrhoea in Iraq are; Norovirus, Shigella spp., Campylo-

bacter, Salmonella spp. and enterotoxigenic *Escherichia coli* (Popoff et al., 2004). Moreover, the majority of diarrhoeal diseases were recorded among children under 5 years old and the situation is further complicated by apparent difficulty and inability to diagnose these disease entities, mainly due to damage or theft of laboratory equipment (Martin et al., 2016). The incidence of typhoid fever has invariably been at a high level since the beginning of the 1990's (Ala'din, 2004). In 2001, up to 21,356 cases of the disease were diagnosed in the whole country. Furthermore, the death rate as a result of typhoid fever is equally high and has reached the level of 10-20% (Ala'din, 2004).. This has been the effect of insufficient access to primary as well as specialized medical services and the impossibility of fast and accurate treatment (WHO 2018).

The prevalence of salmonellosis varies from region to region across Iraq and its neighboring countries as revealed by recent studies where 3% and 34% were reported in Egypt and Saudi Arabia (Moosavy et al., 2015). Epidemiological evidence suggests that there is a direct correlation between contamination of poultry and poultry products with *salmonella* and the occurrence of the disease in humans (Kimura et al., 2004). Many human cases of infections with *S. enteritidis* has followed consumption or contact with eggs and egg products while *S. typhimurium* infections are mostly attributed to other domestic animal species like cattle and poultry meat, as well as environmental contamination with companion animals or infected birds (Kimura et al., 2004). Due to the popularity of these food sources in the region and potential of fomites and carrier animal transmission, the continued persistence of the disease in countries neighboring Iraq such as Iran, Saudi Arabia, Syria and Yemen constitute a significant source of infection to the Iraqi communities (Moosavy et al., 2015). This is even more so considering the humanitarian crises affecting the region, which has resulted in migrations across the region.

### CONCLUSION

A number of incidents in humans as well as different levels of prevalence have been reported among animal species or food materials. In each case, the reported incidence or prevalence was proportionate with either poor healthcare services, immune suppression or poor diagnostic capabilities. Emphasis was also made on the potential role of animal reservoirs as a persistent source of the pathogen to humans and other susceptible animal species. Determination of the actual burden of typhoid fever is important for several reasons; including the fact that the disease is more common among young children and young individuals who constitute the majority of the workforce which is worrisome. Secondly, surveillance for the disease could provide concerned authorities with first-hand information

that will help integrate these surveillance programs and implementation of preventive and control measures for other diseases as well.

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## CONFLICT OF INTEREST

The authors declare that they have no conflict of interests.

## AUTHORS CONTRIBUTION

NA and GB conceived and conducted extensive literature search. HY, AM, RAH, and RAM assisted with other literature materials. LTTL, NZU, BS and AS conducted review of the manuscript and contributed in refining the ideas. All authors reviewed the draft manuscript before submission. All authors read and approved the final manuscript.

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