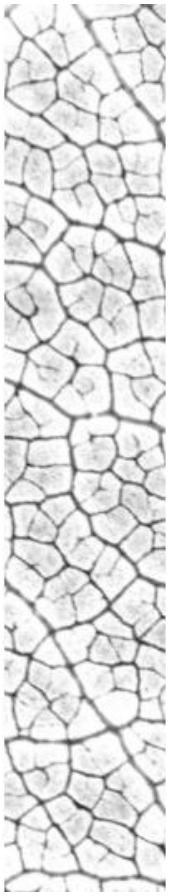

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# Review of pathogenicity and virulence determinants in *Salmonella*

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**Abstract**
*Salmonella* are widely distributed and can be survived in contaminated food and water which are considered a real health hazard. The genus *Salmonella* that associated with human infection cause food-borne and water-borne by consumption of contaminated meat, milk, eggs and water. These organisms grow on mainly nutrient media, the growth of most *Salmonella* strains require minimal media containing sulphate phosphate, ammonium salt for nitrogen, as well as glucose as a source of energy and Carbone. *Salmonella* infections are commonly increased in low income countries. The aim of this review is to review the characteristics of *Salmonella*, the virulence properties of *Salmonella*, pathogenesis and *Salmonella* infection.

**Keywords:** *Salmonella*, enteric fever, virulence factors, pathogenicity

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## INTRODUCTION

The *Salmonella* genus is responsible for many cases of Enteric fever and food poisoning in humans and animals which are continue to be a global public health concern issue worldwide (Alzwghaibi et al. 2018, Diab et al. 2019, Ed-dra et al. 2017, Eguale 2018, Habibi et al. 2018, Ramatla et al. 2019, Zishiri et al. 2016). The *Salmonella* that cause human salmonella infections, which are characterised by fever and bacteraemia, mild watery diarrhoea, dysentery and bloody diarrhoea, focal infections (cholecystitis, hepatitis, nephritis) and typhoid fever (Majowicz et al. 2010). Moreover, Silva et al. (2011) demonstrated that *Salmonella* and *Campylobacter* have been found in eggs, fowl and dairy productsand caused food borne illness. It has been reported that *S. enterica* infections correlated with poultry, pigs and cattle (Dang-Xuan et al. 2019, Fagbamila et al. 2017).

In 2000, typhoid fever worldwide has been estimated in about 21.7 million cases, out of these 216.000 death worldwide (Crump et al. 2004). The incidence of this disease was 13.9-26.9 million cases in 2010 (Buckle et al. 2010). The vaccine is important especially for persons who travel or live in the countries that typhoid fever is occurrence (Adda et al 2016).

For epidemiological studies can be used molecular typing techniques including pulsed-field gel electrophoretic and restriction fragment length polymorphism (RFLP) (Old and Threlfall 1998), polymerase chain reaction (PCR) (Hashimoto et al. 1995), DNA probe and plasmid analysis (Rubin el at. 1989).

### Characteristics of *Salmonella*

*Salmonella* are a member of the family *Enterobacteriaceae*. These organisms are generally oxidase negative, aerobic and anaerobic facultative. Most of them produce hydrogen sulphide.They are negative for urease, indol production and phenylalanine deaminase (Bopp et al. 1999).

*Salmonella* are Gram negative, non-capsulated, non-spore forming, possessing peritrichous flagella except *S. gallinarum* causing fowl typhoid and *S.pullorum* that causes white diarrhoea in chick (Prescott et al. 2008, Xiong et al. 2018). The optimum growth temperature of *Salmonella* is 32-35℃, but some *Salmonella* grow at a temperature between 5℃ and 47℃. However, *Salmonella* are killed at ordinary cooking temperature of 70℃ (Pui et al. 2011).

Serotype analysis is the most common methods that used for identification and classification of *Salmonella* (Old and Threlfall 1998). The genus *Salmonella* includes 2000 serotypes of clinical importance which are reported to be associated with human infection. Depending on the common clinical symptoms, they have been divided in to two groups (Enteric fever and food poisoning) as shown in **Table 1**.

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**Table 1.** *Salmonella* groups of clinical importance

| Enteric fever group | | Food poisoning group | |
|---|---|---|---|
| **Species** | **Key features** | **Species** | **Key features** |
| *S. typhi* | Typhoid | *S. typhimurium* | Gastroenteritis, septicemia |
| *S. paratyhpi*A,B,C | paratyphoid | *S. enteritidis,* | Gastroenteritis, septicemia |
| | | *S.heidelberg,* | Gastroenteritis |
| | | *S.agona,* | Gastroenteritis |
| | | *S.indiana,* | Gastroenteritis |
| | | *S.newport,* | Gastroenteritis |
| | | *S.anatum* | Gastroenteritis, septicemia |

[1]Data from panjarathinam (2007)

## Antigenic Structures

### *Flagellar antigenic H*

It is a heat labile protein. When it mixed with a specific antiserum, destroyed by treatment with alcohol or boiling. It can be stored in formaldehyde at concentration 0.2-0.4%. The H antigen rapidly induces antibody formation following immunisation and infection. H suspensions rapidly agglutinate to produce fluffy and large clumps. Two forms or phases occur by this antigen (phase 1 and phase 2) (Panjarathinam 2007). Moreover, McQuiston et al. (2008) have reported that the phase 1 is specific and is correlated to the immunologic identity of the serovar. Furthermore, the phase 2 has been found to be shared by other serovars such as, in the phase 2 state serovar *S.typhimurium* and *S.paratyphi* B have similar serotype.

### *Somatic antigen O*

It is lipopolysaccharide of the outer membrane. It extracts from cell wall of bacteria by treatment with trichloroacetic acid. Suspension of O antigen forms granular and chalky clumps, when mixed with antisera. However, antibodies that formed by H antigen is more than that of O antibody. Based on O antigens, *Salmonella* can be classified to number of O serogroups such as *S. typhi* is member of D serogroup and *S. paratyphi* A, B, C are member of A, B, $C_1$ serogroups (Panjarathinam 2007, Sussman 2002).

### *Surface antigenic V*

It has been reported that this antigen is related to the virulence. This virulence is expressed by certain *S. paratyphi* and all *S.typhi* strains. However, agglutination reactions and serotyping are valuable in the epidemiological studies of *Salmonella* incidence. Therefore, each strain can be quickly and easily identified (Rezapour-Nasrabad 2019, Sussman 2002).

## Virulence Factors and Pathogenesis

Various virulence factors in *Salmonella* play many roles in the pathogenicity (e.g. plasmids, flagella, adhesion systems, capsule and type 111 secretion systems) (Daigle 2008, Sabbagh et al. 2010).

Typhoid fever illness caused by *S. typhi* and *S. paratyphi* A and B that classified as human-adapted species. Furthermore, strains of *S.typhi* and *S.typhimurium* produce a thermolabile enterotoxin which

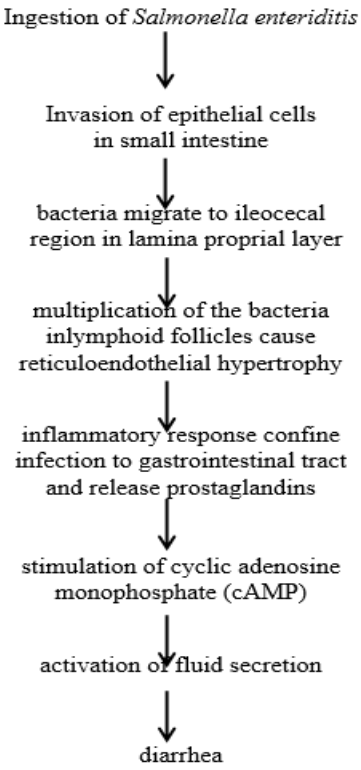


**Fig. 1.** *Salmonella* passage through the body (Goering el al. 2008)

is similar to cholera toxin and *Escherichia coli* heat labile enterotoxin (Clarke et al. 1988). However, *Salmonella* have a thermostable cytotoxin that inhibits synthesis of protein eukaryotic cell and disrupts host cell monolayers (Ashkenazi et al. 1988). It has been expected that endotoxine has a role in symptoms of typhoid (Hornick 1995). Moreover, *Salmonella* pathogenicity island (SPIs) encodes some virulence factors that responsible for invasion, adhesion and toxin genes (Jajere 2019). In the USA, 60% of human infections caused by following serovars *S.enteritidis* (26.1), *S. typhimurium* (22.1), *S.newport* (4.4), *S. heidelberg* (4.8), and *S. hadar* (2.7). In Asia, human typhoid fever incidence has annually reported about 17-33 million cases, 600 000 deaths (Hoseith 2000, Pang 1998). Recently, humans that used antibiotics may predispose for infection. These organisms induce intestinal epithelial cells and then ingested within phagocytic vesicles (Jones et al. 1994). **Fig. 1** shows the passage of *Salmonella* throw the body.

Many clinical pathways can be caused by *Salmonella* including gastroenteritis, bacteraemia, enteric fever and focal infections.

Gastroenteritis may progress to the initial febrile disease related to mucosal and systemic invasion, which can be caused the onset fever and diarrhoea within 24-48 hours after exposure. The majority of *Salmonella* gastroenteritis are self-limited which is including abdominal cramps, watery diarrhoea and vomiting. Thus, *S.typhimurium* is a bacterium that causes

intestinal disease (Fleckenstein and Kopecko 2001). Moreover, Scallan et al. (2011) have suggested that non-typhoid *Salmonella* infections are more incidences in young children, immune-compromised and elderly people.

However, *S. dublin* or *S. choleraesuis* serovars are commonly cause bacteraemia disease that can result in a prolonged febrile without diarrhoea and develops to septic shock and a fatal outcome. A higher recurrent bacteraemia can be occurred mainly in people that are immunocompromised (Levine et al. 1997, Wood et al. 2008). Non-typhoid *Salmonella* infections develop bacteraemia and extra intestinal complications including urinary tract infections, meningitis, endocarditis and pneumonia (Arii et al. 2002).

Enteric fever has been suggested to recognise infection of oral route and systemic invasion happens across the gastrointestinal tract (Adzitey et al. 2019, Levine et al. 1983). It can characterised by abdominal cramps, headache, diarrhoea and fever (Bhan et al. 2005). *S.typhi* and *S.paratyphi* A and B cause typhoid and paratyphoid fever, which are considered highly human hoat-adapted. Most cases in the UK are imported from Bangladesh, India and Pakistan, also in the USA most imported from Latin America and Mexico. The prevention and distribution of typhoid cases can be related to population density. However, it can be reduced by using modern sanitation facilities for water purification and sewage treatment (Mermin et al. 1999).

Furthermore, serovars of *S. typhimurium*, *S. enteritidis*, *S.choleraesuis S. dublin* and *S. virchow* cause focal infections that usually follow gastroenteritis, this case is not important. Endocarditis has been considered the most important local infections, usually causing perforation of the infected value leaflet. However, arterial walls infections caused by *S.choleraesuis* and *S. typhimurium* that have been found in approximately 25% of such cases (Sussman 2002).

*Salmonella enteritidis* serovar *typhimurium* is commonly cause diarrhoea and it is occasionally cause invasive and systemic clinical disease that is not distinctive from typhoid fever caused by *S. typhi*.

## CONCLUSION

*Salmonella* contaminate and survive in the environment and food.

However, non-typhoidal salmonellosis incidence has increased resulting from changes in preparation and storage of food. These organisms are more occur infections in infants, immunocompromised and elderly people. The incidence of typhoid fever is rare in developed countries. Nevertheless, the high typhoid incidence occurs in endemic countries and result from contamination of food and water with sewage. In addition, a poor sanitation and poor personal hygiene play a role in spread of infection. Vaccines can be used to prevent typhoid fever that caused by *S. typhi*.

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