**How to Cite**:
Medhat, A. R., & Aljanaby, A. A. J. (2022). Epidemiology of typhoid fever in Balad City, Iraq. *International Journal of Health Sciences*, *6*(S1), 1049-1063.
https://doi.org/10.53730/ijhs.v6nS1.4834

# Epidemiology of Typhoid Fever in Balad City, Iraq

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***Abstract*---**One thousand nine hundred and twenty individuals admitted to the general teaching hospital in Balad City, suffer from abdominal pain, fever, a headache and nausea. Acute and chronic Typhoid-patients caused by *S.typhi* were diagnosed according to positive blood and stool culture respectively, and using serological test IgG/ IgM. Out of total 1920 individuals, we documented 312 typhoid-patients caused by *S.typhi*; 209(67%) in urban and 103(33%) in rural region and there were 263(84%) acute cases and 49(16%) chronic. The results recorded 180(57.7%) male and 132(42.3%) female and the age group 31-40 was the most infected with 130 cases (41.7%). There was high incidence of typhoid fever in quarter three and two which recorded 96 (30.8%) and 95 (30.5%) cases respectively. In *conclusion:* There was high prevalence of typhoid fever in urban than rural in Balad City and acute infections were dominant. The most cases were in middle age groups in hot seasons.

***Keywords*---**Prevalence, Typhoid fever, *Salmonella Typhi*, Balad City, Iraq.

## Introduction

Typhoid fever also called enteric fever is the most endemic disease in most countries mostly caused by *S.typhi* and the second causative agent is *Salmonella enterica serovars Paratyphi* (*S. Paratyphi*) and the man is the only reservoir for this bacteria (Aljanaby and Medhat, 2017 ; Teferi et al., 2021). Still millions of people were infected with typhoid fever each year, and it is still a major public health issue in low-income nations such as east and west Asian countries (Galgallo et al., 2018). *Salmonella typhi* is gram negative bacterium, motile with peritrichous flagella, $H_2S$ positive and produces black colonies on to SS-agar plate (Masuet-Aumatell and Atouguia, 2021). The contaminated food and water with


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*Manuscript submitted: 27 Nov 2021, Manuscript revised: 18 Feb 2022, Accepted for publication: 09 March 2022*

*S.typhi* are the main sources of infection (Brockett et al., 2020). The number of infective dose and virulence of the organism are the main factors that determinate of severity of infection in population (Milligan et al., 2018; Im et al., 2020). Each year, about 200,000 deaths result from over 25 million cases of typhoid fever worldwide especially in developing countries (Shahid et al., 2021; Awol et al., 2021). The spread of any disease in any population depend on many factors such as health awareness, customs and traditions, population density, virulence of pathogen and use of suitable treatment (Crump, 2019). The incidence of typhoid fever remains high in Africa and Asia, but still the highest incidence in Indian subcontinent (Manesh et al., 2021). Most typhoid-patients are characterized by many symptoms such as; fever, a headache, nausea, abdominal pain and low WBC count (Moser-van der Geest et al., 2019). Positive blood and stool culture are gold standard for diagnosis of *S.typhi* that cause typhoid fever (Kumar and Kumar, 2017). Balad is a religious tourism city in Saladin Governorate it is located 80 kilometers north Baghdad capital of Iraq. Balad is crowded City as compared with other cities because of highly percentage of visitors came to it from most Governorates over the year. Therefore, the aim of this first study in Iraq was to detect the numbers and percentages of typhoid-patients to find out the extent of the spread of this disease and the extent of the potential infection risk of both residents and visitors.

## Materials and Methods

### Study design and patients

The statistical epidemiological study was carried out in Balad City, Iraq from the first January to the end of December 2021 in the central medical laboratory in general teaching hospital in Balad City, two groups of patients infected with typhoid fever caused by *S.typhi* has been studied; acute and chronic infection in two regions; urban and rural. According to seasonal infection, the study was divided to four quarters; January, February and March quarter one. April, May and June as quarter two. July, August and September as quarter three. October, November and December as quarter four (Aljanaby et al., 2022a).

### Area study

Balad is a religious tourism city in Saladin Governorate receive thousands of visitors from most Governorates over the year located between the towns of AL-Ishaqi, Al-Dhuluiya and Yathrib, it is located 80 kilometers north Baghdad capital of Iraq. Include two regions: urban and rural its estimated population about 80,000 people in urban and about 20,000 in rural working in trade, farming and poultry farming (Fig.1).


Figure 1. Balad City Map, urban and rural regions. (Google earth).

**Ethical considerations**

All ethic approvals has been obtained from all typhoid-patients include samples collection such as blood, stool and all personal information.

**Blood and stool collection and culture**

During 2021, 1920 individuals admitted to the general teaching hospital in Balad City, suffer from abdominal pain, fever, a headache and nausea. Ten ml of blood has been collected from all individuals by sterile syringe distributed as follow; 5ml were collected in sterile tube and left at room temperature to clotted and centrifuged at 3000rpm for 5min and 5ml of blood has been mixed with brain heart infusion broth and incubated for 7 days at 37$^{o}$C (Aljanaby and Alhasnawi, 2017; Adam et al; 2019). Ten gram of stool has been collected from the same individuals in sterile container and mixed with 10ml sterile distilled water and incubated aerobically with brain heart infusion broth at 37$^{o}$C for 24h. After end incubation period, blood and stool has been cultured by sterile swab on to blood agar and SS-agar plates and incubated aerobically at 37$^{o}$C for 24h (Aljanaby, 2018; Tack et al., 2019).

**Diagnosis of *S.typhi***

*S.typhi* isolates has been diagnosis according to colony morphology, all standard microbiological tests (Karkey et al., 2018) and Vitek2® system test.

**Diagnosis of acute and chronic infection**

IgG/IgM combo rapid test has been used to diagnosis of acute and chronic infection according to the manufacturing company (CTK Biotech, USA). All typhoid-patients with positive blood culture and IgM positive has been considered as acute infection and those with positive stool culture and IgG positive has been considered as chronic infection (Tarupiwa et al., 2015; Mohammed and Aljanaby, 2020).

**Statically analysis**

Numbers and percentages has been used in statically analysis to compare between urban and rural, acute and chronic, male and female, age groups and quarters by using Graphpad-prism V.12 computer software (Hasan et al., 2021; Aljanaby et al., 2022b).

## Results

**Total patients**

Out of 1920 patients, we recorded 312 typhoid-patients in Balad City; 209 (67%) in urban and 103 (33%) in rural. Out of 312, there were 263 (84%) acute typhoid-patients (positive blood culture/positive IgM) distributed as follow; 173 in urban and 90 in rural. Also, we diagnosed 49 chronic typhoid-patients (positive stool culture/positive IgG) distributed as follow; 36 in urban and 13 in rural (Table 1). Table 2 recorded 180 male (57.7%) and 132 female (42.3%). In urban; 125 male and 84 female. While, there were 55 male and 84 female in rural.

Table 1
Numbers and percentages of typhoid-patients in Balad City from the first January to the end of December 2021

| Type of infection | Urban (100 %) | Rural (100 %) | Total (100 %) |
|---|---|---|---|
| Acute | 173 | 90 | 263 (84) |
| Chronic | 36 | 13 | 49 (16) |
| Total (100 %) | 209(67) | 103 (33) | 312 (100) |

Table 2
Numbers and percentages of typhoid-patients according to sex in Balad City from the first January to the end of December 2021

| Sex | Urban (100 %) | | | Rural (100 %) | | | Total (100 %) |
|---|---|---|---|---|---|---|---|
| Male | Acute | 100 | 125(59.8) | Acute | 48 | 55(53.4) | 180(57.7) |
| | Chronic | 25 | | Chronic | 7 | | |
| Female | Acute | 73 | 84(40.2) | Acute | 42 | 48(46.6) | 132(42.3) |
| | Chronic | 11 | | Chronic | 6 | | |
| Total (100 %) | 209(100) | | | 103(100) | | | 312(100) |
| Total (100 %) | 209 (67) | | | 103 (33) | | | |

**Age groups**

The age group 31-40 was the most infected with typhoid fever 130(41.7%); 89 in urban and 41 in rural. The age group 21-30 took the second place with 72 cases 23% distributed as follow; 54 and 22 in urban and rural respectively. On the other hand, the age group 1-10 recorded the lowest number with 8 cases 2.6%; 6 in urban and 2 in rural (Table 3).

Table 3
Numbers and percentages of typhoid-patients according to age groups in Balad City from the first January to the end of December 2021

| Age group (year) | Urban (100 %) | | | Rural (100 %) | | | Total (100 %) |
|---|---|---|---|---|---|---|---|
| 1-10 | Acute | 5 | 6 (2.9) | Acute | 2 | 2 (1.9) | 8 (2.6) |
| | Chronic | 1 | | Chronic | 0 | | |
| 11-20 | Acute | 22 | 27 (13) | Acute | 19 | 22 (21.3) | 49 (15.7) |
| | Chronic | 5 | | Chronic | 3 | | |
| 21-30 | Acute | 46 | 54 (25.8) | Acute | 16 | 18 (17.5) | 72 (23) |
| | Chronic | 8 | | Chronic | 2 | | |
| 31-40 | Acute | 72 | 89 (42.6) | Acute | 33 | 41 (39.8) | 130 (41.7) |
| | Chronic | 17 | | Chronic | 8 | | |
| 41-50 | Acute | 28 | 33 (15.7) | Acute | 20 | 20 (19.5) | 53 (17) |
| | Chronic | 5 | | Chronic | 0 | | |
| Total (100 %) | 209 (100) | | | 103(100) | | | |
| Total (100 %) | 209 (67) | | | 103 (33) | | | 312(100) |

**Seasonal infections**

The numbers and percentages of typhoid-patients according to the quarters in 2021 were summarized in table 4. There was high incidence of typhoid fever in quarter three and two which recorded 96 (30.8%) and 95 (30.5%) cases respectively. While, quarter four recorded 79 cases (25.3%) and quarter one 42 (13.4%). The results of the present study showed that there were 30 typhoid-patients in urban and 12 in rural in quarter one (Table 5). In quarter two, we recorded 67 and 28 cases in urban and rural respectively (Table 6). Table 7 shows there were 55 cases in urban and 41 in rural. While, the prevalence of typhoid-patients in quarte four were 57 in urban and 22 in rural.

Table 4
Numbers and percentages of typhoid-patients in Balad City according to quarters in 2021

| Quarters | Urban | | Total | Rural | | Total | Total (100%) |
|---|---|---|---|---|---|---|---|
| Quarter one | Acute | 26 | 30 | Acute | 11 | 12 | 42 (13.4) |
| | Chronic | 4 | | Chronic | 1 | | |
| Quarter two | Acute | 58 | 67 | Acute | 24 | 28 | 95 (30.5) |
| | Chronic | 9 | | Chronic | 4 | | |
| Quarter three | Acute | 44 | 55 | Acute | 34 | 41 | 96 (30.8) |
| | Chronic | 11 | | Chronic | 7 | | |
| Quarter four | Acute | 45 | 57 | Acute | 21 | 22 | 79 (25.3) |
| | Chronic | 12 | | Chronic | 1 | | |
| Total (100%) | 209 (67) | | | 103 (33) | | | 312(100) |

Table 5
Numbers and percentages of typhoid-patients in Balad City in quarter one 2021
N=42

| Urban | | | | | |
|---|---|---|---|---|---|
| Age groups (years) | Sex | Type of infection | | Total | Total (100 %) |
| | | Acute | Chronic | | |
| 1-10 | Male | 1 | 0 | 1 | 1 (3.3) |
| | Female | 0 | 0 | 0 | |
| 11-20 | Male | 2 | 0 | 2 | 3 (10) |
| | Female | 1 | 0 | 1 | |
| 21-30 | Male | 5 | 1 | 6 | 8 (26.7) |
| | Female | 2 | 0 | 2 | |
| 31-40 | Male | 8 | 1 | 9 | 14 (46.7) |
| | Female | 5 | 0 | 5 | |
| 41-50 | Male | 2 | 1 | 3 | 4 (13.3) |
| | Female | 0 | 1 | 1 | |
| Total (100 %) | | 26 (86.7) | 4 (13.3) | 30 | 30 (100) |
| Rural | | | | | |
| Age groups (years) | Sex | Type of infection | | Total | Total (100%) |
| | | Acute | Chronic | | |
| 1-10 | Male | 0 | 0 | 0 | 0 (0) |
| | Female | 0 | 0 | 0 | |
| 11-20 | Male | 0 | 0 | 0 | 1 (8.3) |
| | Female | 1 | 0 | 1 | |
| 21-30 | Male | 1 | 0 | 1 | 3 (25) |
| | Female | 2 | 0 | 2 | |
| 31-40 | Male | 4 | 1 | 5 | 7 (58.4) |
| | Female | 2 | 0 | 2 | |
| 41-50 | Male | 1 | 0 | 1 | 1 (8.3) |
| | Female | 0 | 0 | 0 | |
| Total (100%) | | 11 (91.7) | 1 (8.3) | 12 | 12 (100) |

Table 6
Numbers and percentages of typhoid-patients in Balad City in quarter two 2021
N=95

| Urban | | | | | |
|---|---|---|---|---|---|
| Age groups (years) | Sex | Type of infection | | Total | Total (100%) |
| | | Acute | Chronic | | |
| 1-10 | Male | 1 | 0 | 1 | 1 (1.5) |
| | Female | 0 | 0 | 0 | |
| 11-20 | Male | 3 | 1 | 4 | 6 (9) |
| | Female | 2 | 0 | 2 | |
| 21-30 | Male | 8 | 1 | 9 | 17 (25.4) |
| | Female | 7 | 1 | 8 | |
| 31-40 | Male | 17 | 4 | 21 | 34 (50.7) |
| | Female | 12 | 1 | 13 | |

| | | | | | |
|---|---|---|---|---|---|
| 41-50 | Male | 5 | 1 | 6 | 9 (13.4) |
| | Female | 3 | 0 | 3 | |
| Total (100%) | | 58 (86.6) | 9 (13.4) | 67 | 67 (100) |
| Rural | | | | | |
| Age groups (years) | Sex | Type of infection | | Total | Total (100) |
| | | Acute | Chronic | | |
| 1-10 | Male | 0 | 0 | 0 | 1 (3.6) |
| | Female | 1 | 0 | 1 | |
| 11-20 | Male | 2 | 0 | 2 | 2 (7.1) |
| | Female | 0 | 0 | 0 | |
| 21-30 | Male | 4 | 0 | 4 | 6 (21.4) |
| | Female | 2 | 0 | 2 | |
| 31-40 | Male | 7 | 3 | 10 | 16 (57.1) |
| | Female | 5 | 1 | 6 | |
| 41-50 | Male | 3 | 0 | 3 | 3 (10.7) |
| | Female | 0 | 0 | 0 | |
| Total (100 %) | | 24 (85.7) | 4 (14.3) | 28 | 28 (100) |

Table 7
Numbers and percentages of typhoid-patients in Balad City in quarter three 2021
N=96

| Urban | | | | | |
|---|---|---|---|---|---|
| Age groups (years) | Sex | Type of infection | | Total | Total (100%) |
| | | Acute | Chronic | | |
| 1-10 | Male | 2 | 1 | 3 | 4 (7.3) |
| | Female | 1 | 0 | 1 | |
| 11-20 | Male | 3 | 2 | 5 | 7 (12.7) |
| | Female | 2 | 0 | 2 | |
| 21-30 | Male | 3 | 1 | 4 | 9 (16.3) |
| | Female | 4 | 1 | 5 | |
| 31-40 | Male | 14 | 3 | 17 | 28 (50.9) |
| | Female | 9 | 2 | 11 | |
| 41-50 | Male | 2 | 1 | 3 | 7 (12.7) |
| | Female | 4 | 0 | 4 | |
| Total (100%) | | 44 (80) | 11(20) | 55 | 55 (100) |
| Rural | | | | | |
| Age groups (years) | Sex | Type of infection | | Total | Total (100%) |
| | | Acute | Chronic | | |
| 1-10 | Male | 0 | 0 | 0 | 1(2.4%) |
| | Female | 1 | 0 | 1 | |
| 11-20 | Male | 3 | 1 | 4 | 10(24.4) |
| | Female | 4 | 2 | 6 | |
| 21-30 | Male | 1 | 0 | 1 | 5(12.2) |
| | Female | 3 | 1 | 4 | |
| 31-40 | Male | 8 | 2 | 10 | 16(39) |

| | | | | | |
|---|---|---|---|---|---|
| | Female | 5 | 1 | 6 | |
| 41-50 | Male | 5 | 0 | 5 | 9(21.9) |
| | Female | 4 | 0 | 4 | |
| Total (100%) | | 34 (80.5.) | 7 (19.5) | 41 | 41(100) |

Table 8
Numbers and percentages of typhoid-patients in Balad City in quarter four 2021
N=79

| Age groups (years) | Sex | Type of infection | | Total | Total (100%) |
|---|---|---|---|---|---|
| | | Acute | Chronic | | |
| 1-10 | Male | 0 | 0 | 0 | 0(0%) |
| | Female | 0 | 0 | 0 | |
| 11-20 | Male | 6 | 2 | 8 | 11 (19.3%) |
| | Female | 3 | 0 | 3 | |
| 21-30 | Male | 7 | 1 | 8 | 20 (35.1%) |
| | Female | 10 | 2 | 12 | |
| 31-40 | Male | 4 | 4 | 8 | 13 (22.8%) |
| | Female | 3 | 2 | 5 | |
| 41-50 | Male | 7 | 0 | 7 | 13 (22.8%) |
| | Female | 5 | 1 | 6 | |
| Total (100%) | | 45 (78.9%) | 12(21.1%) | 57 | 57 (100%) |
| Age groups (years) | Sex | Type of infection | | Total | Total (100%) |
| | | Acute | Chronic | | |
| 1-10 | Male | 0 | 0 | 0 | 0 (0) |
| | Female | 0 | 0 | 0 | |
| 11-20 | Male | 3 | 0 | 3 | 9 (40.9) |
| | Female | 6 | 0 | 6 | |
| 21-30 | Male | 1 | 0 | 1 | 4 (18.2) |
| | Female | 2 | 1 | 3 | |
| 31-40 | Male | 2 | 0 | 2 | 2 (9.1) |
| | Female | 0 | 0 | 0 | |
| 41-50 | Male | 3 | 0 | 3 | 7 (31.8) |
| | Female | 4 | 0 | 4 | |
| Total (100%) | | 21 (91.3) | 1 (8.7) | 22 | 22 (100) |

**Discussion**

In this epidemiological study, the prevalence of typhoid fever was spatially heterogeneous across a small geographic area, our results proved that there was high incidence of acute typhoid fever in urban than rural (Table 1). These findings were not agreement with many studies those that demonstrated rural were the highest infected with typhoid fever than urban (Breiman et al., 2012; Ho et al., 2016). This may due to the high numbers of population in urban area than rural lead to positive relationship between numbers of population and numbers of infections, the second reason is may be due to high visitors to Balad City over

year those transmitted the infection from different cities (Basnyat et al., 2005; Akullian et al., 2015). Typhoid fever is spread mostly by direct contact with an infected person's faeces, and the danger is greatest in densely populated regions with poor sanitation and access to safe drinking water (Hosoglu et al., 2006; Fusheini and Gyawu, 2020). In small crowded cities, household hygiene and food-water safety and handling habits, as well as close contact with an infected individual, are linked to direct typhoid transmission (Appiah et al., 2020; Ousenu et al., 2021). Because *S.typhi* is entirely human-host-adapted, infection reservoirs exist only among groups of infected individuals (Dougan and Baker, 2014; Gibani et al., 2019) about of which less than 7% develop a chronic carrier condition, allowing the illness to persist throughout inter-epidemic periods (Monack, 2012; Devaraj et al., 2021). In our study, we documented in table 2 that there were 180 male (57.7%) infected with typhoid fever while female were 132 (42.3%). In 2012, a research published in Clinical Infectious Diseases Journal proved the prevalence of typhoid fever was highest among males 59.0% than females 41.0% (Neil et al., 2012). In Iraq Kurdistan, Dworkin et al. (2014) proved that there was 53% of male infected with typhoid fever, while in another study in Uganda the ratio of male-female was 1.68 (Mirembe et al., 2019). The high prevalence among males maybe due to increase daily engage in work more than females, therefore, they are the most contacting with others whether visitors or locals (Sattar et al., 2016; Muhammad et al., 2020). Some of researchers proved that typhoid fever were common in children 1-15 years old (Malik and Malik, 2001; Tran et al., 2005; Rasul et al., 2017) and some recorded that the age group 5-19 was the most infected (Neil et al., 2012). While, other proved the age group 26-35 was the most predominant (Chijioke-Osuji and Duru, 2014). Karthik et al. (2014) recorded that the age groups 18-34 and the 5-9 were the highest infected respectively. Our findings in table 3 has been shown the age group 31-40 was the highest infected (130 cases 41.7%) this might be due to their unhygienic lifestyle and worked in crowded shops, therefore, they are more susceptible to infection than others because of their increased mixing with society and visitors that may be as a good vectors of typhoid fever (Yang et al., 2018; Brainard et al., 2018; Fusheini and Gyawu, 2020). Our findings in table 4 proved there was high incidence of typhoid fever in quarter three and two which recorded 96 (30.8%) and 95 (30.5%) cases respectively, followed by the number of cases recorded in the fourth quarter and lowest during the first quarter over 2021, the prevalence of numbers and percentages of patients infected with typhoid fever in four quarters has been summarized in tables 5-8. Our results consistent with previous studies (Labi et al., 2014; Saad et al., 2018; Fusheini et al., 2020). Enteric fever seems to follow a seasonal pattern in numerous Asian and African nations, with peak occurrence around the same time each year and most researchers recorded there was high incidence of typhoid fever in hot and warm seasons over year (Karkey et al., 2010; Das et al., 2014; Pitzer et al., 2015; Duy et al., 2016). The high prevalence of typhoid fever in Balad population in hot seasons may be due to drinking a lot of water and iced juices and eating icy food such as ice cream, which may be contaminated with *S.typhi* (Brockett et al., 2020; Essayagh et al., 2020). The causes of enteric fever's seasonal prevalence are not fully understood, temperature and rainfall may play an influence according to some published data (Wang et al., 2013; Sikorski et al., 2020). In summary, there was high outbreak of typhoid fever in Balad City in 2021 according to small population especially in hot seasons. Therefore, we recommend health awareness should be prioritized, and

people must be educated about the danger of typhoid fever and visitors being examined on a regular basis to prevent transmitted infection from and to City.

## Conclusions

According to the small population, there was high prevalence of typhoid fever in urban than rural in Balad City and acute infections were dominant. The most cases were in middle age groups in hot seasons.

## Acknowledgment

Special thanks to the central medical laboratory in general teaching hospital in Balad City for all assistance that introduced to researchers to finish this work.

## Funding and assistance

This study was the outcome of an independent study that received no financial assistance.

## Conflict of interest

There is no conflict of interest in this work.

## References

Adam, R.W., Al-Labban, H.M.Y., Aljanaby, A.A.J. and Abbas, N.A., 2019. Synthesis, Characterization and Antibacterial Activity of Some Novel 1, 2, 3-Triazol-Chalcone Derivatives from N-Acetyl-5H-Dibenzo [b, f] Azepine-5-Carboxamide. *Nano Biomed. Eng*, *11*(2), pp.99-110. doi: 10.5101/nbe.v11i2.p99-110.

Akullian, A., Ng'eno, E., Matheson, A.I., Cosmas, L., Macharia, D., Fields, B., Bigogo, G., Mugoh, M., John-Stewart, G., Walson, J.L. and Wakefield, J., 2015. Environmental transmission of typhoid fever in an urban slum. PLoS neglected tropical diseases, 9(12), p.e0004212. doi:10.1371/journal.pntd.0004212

Aljanaby, A.A.J. and Alhasnawi, H.M.R.J., 2017. phenotypic and molecular characterization of multidrug resistant *Klebsiella pneumoniae* isolated from different clinical sources in Al-Najaf Province-Iraq. *Pak. J. Biol. Sci*, *20*(5), pp.217-232. doi.org/10.3923/pjbs.2017.217.232.

Aljanaby, A.A.J. and Medhat, A.R., 2017. prevalence of some antimicrobials resistance associated-genes in Salmonella typhi isolated from patients infected with typhoid fever. *J. Biol. Sci*, *17*(4), pp.171-184. doi: 10.3923/jbs.2017.171.184

Aljanaby, A.A.J., 2018. Antibacterial activity of an aqueous extracts of *Alkanna tinctoria* roots against drug resistant aerobic pathogenic bacteria isolated from patients with burns infections. Romj. (7):1; 1-6. doi: 10.15275/rusomj.2018.0104

Aljanaby, A.A.J., Al-Faham, Q.M.H., Aljanaby, I.A.J. and Hasan, T.H., 2022a. Epidemiological study of *Mycobacterium Tuberculosis* in Baghdad Governorate, Iraq. *Gene Reports*, (26):1-5.101467. https://doi.org/10.1016/j.genrep.2021.101467

Aljanaby, A.A.J., Al-Faham, Q.M.H., Aljanaby, I.A.J. and Hasan, T.H., 2022b. Immunological role of cluster of differentiation 56 and cluster of differentiation 19 in patients infected with mycobacterium tuberculosis in Iraq. *Gene Reports*, p.101514.

Appiah, G.D., Chung, A., Bentsi-Enchill, A.D., Kim, S., Crump, J.A., Mogasale, V., Pellegrino, R., Slayton, R.B. and Mintz, E.D., 2020. Typhoid outbreaks, 1989–2018: implications for prevention and control. *The American journal of tropical medicine and hygiene*, *102*(6), p.1296. doi: 10.4269/ajtmh.19-0624

Awol, R.N., Reda, D.Y. and Gidebo, D.D., 2021. Prevalence of Salmonella enterica serovar Typhi infection, its associated factors and antimicrobial susceptibility patterns among febrile patients at Adare general hospital, Hawassa, southern Ethiopia. *BMC infectious diseases*, *21*(1), pp.1-9. doi: 10.1186/s12879-020-05726-9.

Basnyat, B., Maskey, A.P., Zimmerman, M.D. and Murdoch, D.R., 2005. Enteric (typhoid) fever in travelers. *Clinical infectious diseases*, pp.1467-1472. doi.org/10.1086/497136

Brainard, J., D'hondt, R., Ali, E., Van den Bergh, R., De Weggheleire, A., Baudot, Y., Patigny, F., Lambert, V., Zachariah, R., Maes, P. and Kuma-Kuma Kenge, D., 2018. Typhoid fever outbreak in the Democratic Republic of Congo: Case control and ecological study. *PLoS neglected tropical diseases*, *12*(10), p.e0006795. doi: 10.1371/journal.pntd.0006795

Breiman, R.F., Cosmas, L., Njuguna, H., Audi, A., Olack, B., Ochieng, J.B., Wamola, N., Bigogo, G.M., Awiti, G., Tabu, C.W. and Burke, H., 2012. Population-based incidence of typhoid fever in an urban informal settlement and a rural area in Kenya: implications for typhoid vaccine use in Africa. *PloS one*, *7*(1), p.e29119. doi: 10.1371/journal.pone.0029119

Brockett, S., Wolfe, M.K., Hamot, A., Appiah, G.D., Mintz, E.D. and Lantagne, D., 2020. Associations among Water, Sanitation, and Hygiene, and Food Exposures and Typhoid Fever in Case–Control Studies: A Systematic Review and Meta-Analysis. *The American journal of tropical medicine and hygiene*, *103*(3), p.1020. doi: 10.4269/ajtmh.19-0479

Chijioke-Osuji, C.C. and Duru, F.C., 2014. Prevalence of antibody titre in healthy individual and enteric fever patients in Owerri, Nigeria. *Journal of Public Health and Epidemiology*, *8*(6), pp.192-196. doi: https:// doi.org/10.5897/JPHE2013.0612

Crump, J.A., 2019. Progress in typhoid fever epidemiology. *Clinical Infectious Diseases*, *68*(Supplement_1), pp.S4-S9. doi: 10.1093/cid/ciy846

Das, S.K., Chisti, M.J., Afrad, M.H., Malek, M.A., Ahmed, S., Ferdous, F., Farzana, F.D., Das, J., Shahunja, K.M., Afroze, F. and Salam, M.A., 2014. Gastroenteritis due to typhoidal Salmonella: a decade of observation at an urban and a rural diarrheal disease hospital in Bangladesh. *BMC infectious diseases*, *14*(1), pp.1-8. doi: 10.1186/1471-2334-14-435.

Devaraj, A., González, J.F., Eichar, B., Thilliez, G., Kingsley, R.A., Baker, S., Allard, M.W., Bakaletz, L.O., Gunn, J.S. and Goodman, S.D., 2021. Enhanced biofilm and extracellular matrix production by chronic carriage versus acute isolates of Salmonella Typhi. *PLoS Pathogens*, *17*(1), p.e1009209. doi: 10.1371/journal.ppat.1009209

Dougan, G. and Baker, S., 2014. Salmonella enterica serovar Typhi and the pathogenesis of typhoid fever. *Annual review of microbiology*, *68*, pp.317-336. doi: 10.1146/annurev-micro-091313-103739

Duy, P.T., Thompson, C.N., Rabaa, M.A., Sona, S., Sopheary, S., Kumar, V., Moore, C., Nga, T.V.T., Wijedoru, L., Holt, K.E. and Wong, V., 2016. The Molecular and Spatial Epidemiology of Typhoid Fever in Rural Cambodia. doi: 10.1371/journal.pntd.0004785

Dworkin, J., Saeed, R., Mykhan, H., Kanan, S., Farhad, D., Ali, K.O., Abdulwahab, R.H.K., Palardy, J. and Neill, M.A., 2014. Burden of typhoid fever in Sulaimania, Iraqi Kurdistan. *International Journal of Infectious Diseases*, *27*, pp.70-73. http://dx.doi.org/10.1016/j.ijid.2014.07.005

Essayagh, M., Rhaffouli, A.E., Essayagh, S. and Essayagh, T., 2020. Epidemiology profil of fever typhoid in Meknes (Morocco) 2013-2016. *Revue D'epidemiologie et de Sante Publique*, *68*(1), pp.45-49. doi: 10.1016/j.respe.2019.09.006

Fusheini, A. and Gyawu, S.K., 2020. Prevalence of Typhoid and Paratyphoid Fever in the Hohoe Municipality of the Volta Region, Ghana: A Five-Year Retrospective Trend Analysis. Annals of Global Health, 86(1). doi: 10.5334/aogh.2833

Galgallo, D.A., Roka, Z.G., Boru, W.G., Abill, K. and Ransom, J., 2018. Investigation of a typhoid fever epidemic in Moyale sub-county, Kenya, 2014–2015. *Journal of Health, Population and Nutrition*, *37*(1), pp.1-5. doi: 10.1186/s41043-018-0144-2

Gibani, M.M., Jones, E., Barton, A., Jin, C., Meek, J., Camara, S., Galal, U., Heinz, E., Rosenberg-Hasson, Y., Obermoser, G. and Jones, C., 2019. Investigation of the role of typhoid toxin in acute typhoid fever in a human challenge model. *Nature medicine*, *25*(7), pp.1082-1088. doi: 10.1038/s41591-019-0505-4

Hasan, T.H., Alasedi, K.K. and Aljanaby, A.A.J., 2021. A Comparative Study of Prevalence Antimicrobials Resistance Klebsiella pneumoniae among Different Pathogenic Bacteria Isolated from Patients with Urinary Tract Infection in Al-Najaf City, Iraq. *Latin American Journal of Pharmacy*, 40 (special issue): 174-8. http://www.latamjpharm.org/previous_issue.php?vol=0&num=1

Ho, J., Odhiambo, G., Meng'anyi, L.W., Musuva, R.M., Mule, J.M., Alaly, Z.S., Odiere, M.R., Mwinzi, P.N. and Ganley-Leal, L., 2016. Evaluation of medicine retail outlets for sale of typhoid fever vaccine among adults in two urban and rural settings in western Kenya: a proof-of-concept study. *BMC health services research*, *16*(1), pp.1-8. doi: 10.1186/s12913-016-1788-5

Hosoglu, S., Celen, M.K., Geyik, M.F., Akalin, S., Ayaz, C., Acemoglu, H. and Loeb, M., 2006. Risk factors for typhoid fever among adult patients in Diyarbakir, Turkey. *Epidemiology & Infection*, *134*(3), pp.612-616. doi: 10.1017/S0950268805005583

Im, J., Islam, M.T., Kim, D.R., Ahmmed, F., Chon, Y., Zaman, K., Khan, A.I., Ali, M., Sur, D., Kanungo, S. and Dutta, S., 2020. Protection conferred by typhoid fever against recurrent typhoid fever in urban Kolkata. *PLoS neglected tropical diseases*, *14*(8), p.e0008530. doi: 10.1371/journal.pntd.0008530

Karkey, A., Arjyal, A., Anders, K.L., Boni, M.F., Dongol, S., Koirala, S., My, P.V.T., Nga, T.V.T., Clements, A.C., Holt, K.E. and Duy, P.T., 2010. The burden and characteristics of enteric fever at a healthcare facility in a densely populated area of Kathmandu. *PloS one*, *5*(11), p.e13988. doi: 10.1371/journal.pone.0013988

Karkey, A., Thwaites, G.E. and Baker, S., 2018. The evolution of antimicrobial resistance in Salmonella Typhi. *Current opinion in gastroenterology*, *34*(1), pp.25-30. doi: 10.1097/MOG.0000000000000406.

Karthik, L., Kumar, G., Keswani, T., Bhattacharyya, A., Chandar, S.S. and Bhaskara Rao, K.V., 2014. Protease inhibitors from marine actinobacteria as a potential source for antimalarial compound. *PloS one*, *9*(3), p.e90972. doi: https://doi.org/10.1371/journal. pone.0029119

Kumar, P. and Kumar, R., 2017. Enteric Fever. Indian journal of pediatrics. 84(3):227-230. doi: 10.1007/s12098-016-2246-4

Labi, A.K., Obeng-Nkrumah, N., Addison, N.O. and Donkor, E.S., 2014. Salmonella blood stream infections in a tertiary care setting in Ghana. *BMC infectious diseases*, *14*(1), pp.1-10. doi: https://doi.org/10.1186/s12879-014-0697-7

Malik, A.S. and Malik, R.H., 2001. Typhoid fever in Malaysian children. *The Medical journal of Malaysia*, *56*(4), pp.478-490. https://pubmed.ncbi.nlm.nih.gov/12014769/

Manesh, A., Meltzer, E., Jin, C., Britto, C., Deodhar, D., Radha, S., Schwartz, E. and Rupali, P., 2021. Typhoid and paratyphoid fever: a clinical seminar. Journal of Travel Medicine, 28(3), p.taab012. doi: 10.1093/jtm/taab012

Masuet-Aumatell, C. and Atouguia, J., 2021. Typhoid fever infection–Antibiotic resistance and vaccination strategies: A narrative review. *Travel Medicine and Infectious Disease*, *40*, p.101946. doi: 10.1016/j.tmaid.2020.101946

Milligan, R., Paul, M., Richardson, M. and Neuberger, A., 2018. Vaccines for preventing typhoid fever. *Cochrane Database of Systematic Reviews*, (5). doi: 10.1002/14651858.CD001261.pub4

Mirembe, B.B., Mazeri, S., Callaby, R., Nyakarahuka, L., Kankya, C. and Muwonge, A., 2019. Temporal, spatial and household dynamics of Typhoid fever in Kasese district, Uganda. *Plos one*, *14*(4), p.e0214650. doi: 10.1371/journal.pone.0214650

Mohammed, E.H., Aljanaby, A.A.J., 2020. Galectin3 and cd16 play an important immunological role in patients infected with salmonella typhi. International Journal of Research in Pharmaceutical Sciences, 2020, 11(3):4162–4169. doi: https://doi.org/10.26452/ijrps.v11i3.2623

Monack, D.M., 2012. Salmonella persistence and transmission strategies. *Current opinion in microbiology*, *15*(1), pp.100-107. doi: 10.1016/j.mib.2011.10.013

Moser-van der Geest, N., Schibli, A. and Huber, L.C., 2019. CME: Typhus abdominalis–Klinik, Diagnostik, Therapie und Prävention. *Praxis*. doi: 10.1024/1661-8157/a003319

Muhammad, E.N., Mutalip, M.H.A., Hasim, M.H., Paiwai, F., Pan, S., Mahmud, M.A.F., Yeop, N., Tee, G.H. and Aris, T., 2020. The burden of typhoid fever in Klang Valley, Malaysia, 2011–2015. *BMC infectious diseases*, *20*(1), pp.1-10. DOI: 10.1186/s12879-020-05500-x

Neil, K.P., Sodha, S.V. and Lukwago, L., O-tipo, S., Mikoleit, M., Simingron, SD, 2012. A large outbreak of Typhoid Fever associated with a high rate of intestianal perforation in kasese district, uganda, 2008-2009, Clinical Infectious Diseases Advance, pp.1-9. doi: https://doi.org/10.1093/cid/ cis025

Ousenu, K., Ali, I.M., Sama, L.F., Ndam, M.N., Tchouangueu, T.F. and Tume, C.B., 2021. A Cross-Sectional Comparative Study of the Performance of the Widal Test and the Typhidot Immunoassay for Typhoid Fever Diagnosis in the West Region of Cameroon. *Canadian Journal of Infectious Diseases and Medical Microbiology*, *2021*. doi: 10.1155/2021/8279122

Pitzer, V.E., Feasey, N.A., Msefula, C., Mallewa, J., Kennedy, N., Dube, Q., Denis, B., Gordon, M.A. and Heyderman, R.S., 2015. Mathematical modeling to

assess the drivers of the recent emergence of typhoid fever in Blantyre, Malawi. *Clinical Infectious Diseases*, *61*(suppl_4), pp.S251-S258. doi: 10.1093/cid/civ710

Rasul, F., Sughra, K., Mushtaq, A., Zeeshan, N., Mehmood, S. and Rashid, U., 2017. Surveillance report on typhoid fever epidemiology and risk factor assessment in district Gujrat, Punjab, Pakistan. *Biomedical Research*, *28*(8), pp.1-6. https://www.alliedacademies.org/articles/surveillance-report-on-typhoid-fever-epidemiology-and-risk-factor-assessment-in-district-gujrat-punjab-pakistan-8198.html

Saad, N.J., Lynch, V.D., Antillón, M., Yang, C., Crump, J.A. and Pitzer, V.E., 2018. Seasonal dynamics of typhoid and paratyphoid fever. *Scientific reports*, *8*(1), pp.1-9. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5932015/

Sattar, A.A., Chowdhury, M.S.J.H., Yusuf, M.A., Jesmin, S., Ara, S. and Islam, M.B., 2016. Age and gender difference of typhoid Fever among paediatric patients attended at a tertiary care hospital in Bangladesh. *Bangladesh Journal of Infectious Diseases*, *3*(2), pp.36-39. DOI: https://doi.org/10.3329/bjid.v3i2.33830

Shahid, S., Mahesar, M., Ghouri, N. and Noreen, S., 2021. A review of clinical profile, complications and antibiotic susceptibility pattern of extensively drug-resistant (XDR) Salmonella Typhi isolates in children in Karachi. *BMC Infectious Diseases*, *21*(1), pp.1-9. doi: 10.1186/s12879-021-06599-2

Sikorski, M.J., Desai, S.N., Tupua, S., Thomsen, R.E., Han, J., Rambocus, S., Nimarota-Brown, S., Punimata, L., Tusitala, S., Sialeipata, M. and Hoffman, S.A., 2020. Tenacious endemic typhoid fever in samoa. *Clinical Infectious Diseases*, *71*(Supplement_2), pp.S120-S126. doi: 10.1093/cid/ciaa314

Tack, B., Phoba, M.F., Van Puyvelde, S., Kalonji, L.M., Hardy, L., Barbé, B., Van der Sande, M.A., Monsieurs, E., Deborggraeve, S., Lunguya, O. and Jacobs, J., 2019. Salmonella Typhi from blood cultures in the Democratic Republic of the Congo: a 10-year surveillance. *Clinical Infectious Diseases*, *68*(Supplement_2), pp.S130-S137. doi: 10.1093/cid/ciy1116

Tarupiwa, A., Tapera, S., Mtapuri-Zinyowera, S., Gumbo, P., Ruhanya, V., Gudza-Mugabe, M., Majuru, N.X. and Chin'ombe, N., 2015. Evaluation of TUBEX-TF and OnSite Typhoid IgG/IgM Combo rapid tests to detect Salmonella enterica serovar Typhi infection during a typhoid outbreak in Harare, Zimbabwe. *BMC research notes*, *8*(1), pp.1-4. doi: 10.1186/s13104-015-1015-1

Teferi, M.Y., El-Khatib, Z., Alemayehu, E.A., Adane, H.T., Andualem, A.T., Hailesilassie, Y.A., Kebede, A.S., Asamoah, B.O., Boltena, M.T. and Shargie, M.B., 2021. Prevalence and antimicrobial susceptibility level of typhoid fever in Ethiopia: A systematic review and meta-analysis. *Preventive Medicine Reports*, p.101670. doi: 10.1016/j.pmedr.2021.101670

Tran, H.H., Bjune, G., Nguyen, B.M., Rottingen, J.A., Grais, R.F. and Guerin, P.J., 2005. Risk factors associated with typhoid fever in Son La province, northern Vietnam. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *99*(11), pp.819-826. Doi: 10.1016/j.trstmh.2005.05.007

Wang, J.F., Wang, Y., Zhang, J., Christakos, G., Sun, J.L., Liu, X., Lu, L., Fu, X.Q., Shi, Y.Q. and Li, X.M., 2013. Spatiotemporal transmission and determinants of typhoid and paratyphoid fever in Hongta District, Yunnan Province, China. *PLoS neglected tropical diseases*, *7*(3), p.e2112. doi: 10.1371/journal.pntd.0002112

Yang, Y.A., Chong, A. and Song, J., 2018. Why is eradicating typhoid fever so challenging: implications for vaccine and therapeutic design. *Vaccines*, *6*(3), p.45. doi: 10.3390/vaccines6030045