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Epidemiological Analysis of Environmental and Behavioral Risk Factors for Typhoid Fever Occurrence: A Case-Control Study at RSU PKU Muhammadiyah Delanggu, Klaten

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Abstract

This study aimed to analyze risk factors associated with the occurrence of typhoid fever at RSU PKU Muhammadiyah Delanggu, Klaten. The study employed a quantitative design with a case-control approach, involving 48 respondents consisting of 24 typhoid fever cases and 24 non-typhoid fever controls with a 1:1 ratio. The research instrument was a questionnaire covering respondent characteristics, personal hygiene, eating habits outside the home, and level of knowledge. Data analysis was conducted using univariate and bivariate analyses with the Odds Ratio (OR) test and a 95% Confidence Interval (CI). The results showed that gender was not significantly associated with the occurrence of typhoid fever (OR = 1.18; 95% CI: 0.38-3.66). Poor personal hygiene (OR = 11.40; 95% CI: 2.96-43.80), frequent eating outside the home (OR = 15.00; 95% CI: 3.64-61.90), and low level of knowledge (OR = 7.29; 95% CI: 2.04-26.10) were proven to be significant risk factors for typhoid fever. Therefore, promotive and preventive interventions focusing on hygienic behavior, food safety, and improvement of public knowledge are necessary to reduce the incidence of typhoid fever.

Keywords: *Typhoid Fever, Risk Factors, Odds Ratio, Confidence Interval.*

INTRODUCTION

Typhoid fever remains a major infectious disease and a persistent public health challenge, particularly in low and middle-income countries (Gashaw & Jambo, 2022). The disease affects individuals of all age groups, however, children are reported to be more susceptible compared to adults. Before the year 2000, the global burden of typhoid fever was estimated at approximately 16 million cases annually, with nearly 600,000 deaths worldwide. This burden increased in 2000, reaching an estimated 21.7 million cases and 216,000 deaths, and continued to rise to approximately 26.9 million cases and 200,000 deaths by 2010. Although more recent estimates between 2017 and 2024 show a gradual decline in incidence, typhoid fever continues to pose a significant threat to population health (Boakye *et al*., 2025).

Despite advancements in medical treatment and public health interventions, typhoid fever remains endemic in many regions, especially in Asia and sub-Saharan Africa (Kim *et al*., 2022). Billions of people continue to live in environments that facilitate exposure to Salmonella enterica serovar Typhi due to inadequate water and sanitation systems (Bisola *et al*., 2024). Improvements in food safety, water quality, hygiene, and sanitation have been shown to reduce transmission; however, these

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improvements are not evenly distributed across populations. Vaccination has emerged as an important preventive strategy, particularly with the introduction of typhoid conjugate vaccines (TCVs) (Nampota *et al*., 2023). The World Health Organization recommends TCVs for all age groups because of their superior immunogenicity and longer duration of protection compared to older vaccines.

Typhoid fever transmission is multifactorial and involves interactions between environmental, behavioral, socioeconomic, and host-related factors (Nakisuyi *et al*., 2023). Waterborne transmission remains one of the most important pathways, particularly in settings where access to safe drinking water is limited or unreliable (Sawyer *et al*, 2025). Studies have shown that the use of untreated water, intermittent water supply systems, and unsafe water storage practices significantly increase the risk of infection (Kim *et al*., 2023). Foodborne transmission also plays role, especially through the consumption of food prepared under poor hygienic conditions or sold by unregulated street vendors. These transmission pathways are often reinforced by inadequate sanitation infrastructure and poor hygiene practices (Salamandane *et al*., 2023).

Numerous epidemiological and modeling studies have showed that typhoid fever incidence is strongly influenced by environmental, demographic, and socioeconomic determinants (Ren *et al*., 2023). Geospatial analyses consistently show associations between disease occurrence and population density, access to improved water sources, and sanitation facilities (Gething *et al*., 2023). Food related exposures, particularly the consumption of raw or improperly handled foods, further contribute to infection risk, alongside climate variability such as rainfall patterns and seasonal temperature changes. Demographic vulnerability is well documented, with young children and older adults at higher risk due to immune system limitations and exposure patterns. In addition, low socioeconomic status, limited education, and occupational exposures such as farming, sewage handling, and health care work increase the likelihood of contact with contaminated environments (Castillo *et al*., 2021).

Hygiene and sanitation practices are central to interrupting the fecal-oral transmission cycle of Salmonella Typhi (Boakye *et al*., 2025). Poor handwashing behavior, especially the absence of soap use after defecation or before food preparation, significantly increases infection risk (Soboksa *et al*., 2022). Inadequate sanitation systems, including open defecation, pit latrines, and damaged sewer infrastructure, facilitate environmental contamination and pathogen spread. Improper disposal of human and solid waste further exacerbates transmission, particularly in flood prone and densely populated areas where sewage overflow can contaminate water sources and agricultural land. Strengthening household and community level sanitation therefore remains a priority for effective typhoid control (Aiemjoy *et al*., 2022).

Additional risk factors include antimicrobial use, host susceptibility, asymptomatic carriers, travel exposure, and environmental conditions. Prior antibiotic use has been associated with increased infection risk, particularly in multidrug-resistant S. Typhi strains, which pose ongoing challenges for disease control (da Silva *et al*., 2022). Host related factors such as genetic predisposition, chronic illness, and immunosuppression further influence susceptibility, while household contact with infected individuals increases transmission through prolonged bacterial shedding. Travel to endemic areas, low vaccination coverage, seasonal variation, flooding, urbanization, and population growth also contribute to disease spread (Thalia, 2024).

Although numerous studies in Indonesia have identified general risk factors for typhoid fever, evidence focusing on semi-urban areas undergoing rapid lifestyle transitions remains limited. Delanggu, Klaten represents a semi-urban setting characterized by increasing population mobility, growing reliance on commercially prepared food, and heterogeneous access to sanitation facilities, which may generate a distinct local risk profile compared to rural or fully urban areas (Maphosa & Moyo, 2025). Changes in dietary behavior, particularly the increasing frequency of eating outside the home, combined with suboptimal personal hygiene practices, may amplify exposure to contaminated food and water sources; however, these localized behavioral and environmental dynamics have not been sufficiently explored in previous typhoid fever studies in Indonesia. Furthermore, the role of knowledge as a determinant of typhoid fever risk is theoretically grounded in health behavior frameworks such as the Health Belief Model and the Theory of Planned Behavior, which posit that knowledge shapes perceptions, attitudes, and behavioral intentions related to hygiene and food safety practices, thereby influencing individual susceptibility to infection (Natour *et al*., 2023).

This study was conducted in response to the persistent occurrence of typhoid fever cases at RSU PKU Muhammadiyah Delanggu, Klaten, despite the availability of established preventive strategies and clinical management guidelines. The continued incidence of typhoid fever indicates that local risk factors particularly those related to water sources, food consumption habits, personal hygiene practices, and socioeconomic conditions may still contribute significantly to disease transmission within the community. Therefore, this study seeks to address the existing knowledge gap by analyzing the epidemiological profile of environmental and behavioral risk factors in a semi-urban Indonesian setting, while integrating health behavior theory to better explain the role of knowledge in shaping typhoid fever risk. Specifically, this research examines demographic characteristics, personal hygiene, eating habits outside the home, and knowledge levels in relation to typhoid fever incidence, as well as determining which factors pose the greatest risk in this hospital-based case control setting.

RESEARCH METHOD

This study employed a quantitative research design using a case-control approach (Wittenberg *et al*., 2020). The research was conducted at RSU PKU Muhammadiyah Delanggu, Klaten. The case population consisted of all typhoid fever patients who were recorded and received treatment at RSU PKU Muhammadiyah Delanggu, Klaten during a one-month observation period, with a total of 24 cases. Sampling for the case group was carried out using a total sampling technique, in which all typhoid fever patients who met the inclusion criteria were included as study respondents (Muche *et al*., 2024). The inclusion criteria were patients diagnosed with typhoid fever based on medical records and those who were willing to participate in the study. The exclusion criteria included typhoid fever patients with comorbidities such as Diabetes Mellitus and respondents who were unwilling to participate in the study.

The control group consisted of patients without a diagnosis of typhoid fever who visited the same hospital during the same study period. Controls were selected using an accidental sampling technique, with eligibility restricted to patients presenting with non-infectious or non-gastrointestinal complaints, to minimize misclassification and reduce the likelihood of selection bias. Controls were recruited from the same source population as cases to ensure comparability in terms of healthcare access and environmental exposure.

The sample size in this study was determined using a 1:1 case-control ratio, resulting in 24 case respondents and 24 control respondents, with a total of 48 respondents. This ratio was selected to maximize statistical efficiency and comparability between groups within the constraints of a limited number of confirmed cases during the study period. Although the sample size was relatively small, it is considered adequate for exploratory epidemiological analysis in a hospital-based case-control study, particularly given the magnitude of effect sizes observed in previous studies examining behavioral and hygiene-related risk factors for typhoid fever (Liu *et al*., 2020; Muche *et al*., 2024).

The research instrument used was a structured questionnaire that included respondent characteristics and variables related to personal hygiene, eating habits outside the home, and knowledge (Ma *et al*., 2020). The questionnaire was adapted from previously published instruments used in typhoid fever and foodborne disease studies and was reviewed by public health experts to ensure content validity. A pilot test was conducted prior to data collection to assess clarity and consistency of items, and internal reliability testing yielded acceptable Cronbach's alpha values ($\alpha > 0.70$) for the main behavioral domains, showing satisfactory reliability.

Data analysis was conducted using univariate analysis to describe the frequency distribution of each variable and bivariate analysis using the Odds Ratio (OR) test with a 95% confidence interval (95% CI) to determine the magnitude of risk factors associated with the occurrence of typhoid fever (Liu *et al*., 2020).

Table 1. Operational Definitions of Personal Hygiene and Eating Habits Outside

Variable	Operational Definition	Indicators	Categorization
Personal Hygiene	Individual practices related to cleanliness and infection prevention in daily activities	Handwashing before eating and after defecation, use of soap, cleanliness of fingernails, food handling hygiene at home	Good: ≥75% of indicators met; Poor: <75% of indicators met
Eating Habits Outside the Home	Frequency of consuming food prepared outside the household	Frequency of eating street food or food from restaurants/food stalls per week	Frequent (High Risk): ≥3 times/week; Infrequent (Low Risk): <3 times/week

RESULTS

Respondent Characteristics

This study involved a total of 48 respondents, 24 typhoid fever cases and 24 control subjects without typhoid fever, with a case control ratio of 1:1. The characteristics of respondents analyzed in this study included gender, level of education, and occupation. The distribution of respondent characteristics and study variables is presented in Tables 1 to 2.

Table 1. Distribution of Cases and Controls by Gender

Gender	Cases (n)	Cases (%)	Controls (n)	Controls (%)	Total (n)	Total (%)
Male	14	58.3	13	54.2	27	56.3
Female	10	41.7	11	45.8	21	43.7
Total	24	100	24	100	48	100

Based on Table 1, it is known that out of 27 respondents (56.3%) who were male, 14 respondents (58.3%) were in the case group and 13 respondents (54.2%) were in the control group. Meanwhile, among 21 respondents (43.7%) who were female, 10 respondents (41.7%) were in the case group and 11 respondents (45.8%) were in the control group.

Table 2. Distribution of Cases and Controls by Educational Level

Educational Level	Cases (n)	Cases (%)	Controls (n)	Controls (%)	Total (n)	Total (%)
Primary School	2	8.3	1	4.2	3	6.3
Junior High School	2	8.3	2	8.3	4	8.3
Senior High School	18	75.0	17	70.8	35	72.9
Higher Education	2	8.3	4	16.7	6	12.5
Total	24	100	24	100	48	100

Based on Table 2, it is known that the highest level of education in both the typhoid fever case group and the control group (non-typhoid fever) was senior high school or equivalent, with 18 respondents (75.0%) in the case group and 17 respondents (70.8%) in the control group.

Table 3. Distribution of Cases and Controls by Occupation

Occupation	Cases (n)	Cases (%)	Controls (n)	Controls (%)	Total (n)	Total (%)
Housewife	5	20.8	4	16.7	9	18.8
Self-employed	6	25.0	5	20.8	11	22.9
Private Employee	11	45.8	10	41.7	21	43.8
Civil Servant / Military / Police	2	8.3	4	16.7	6	12.5
Unemployed	0	0.0	1	4.2	1	2.1
Others	0	0.0	0	0.0	0	0.0
Total	24	100	24	100	48	100

Univariate Analysis

The results are presented through univariate analysis to describe the distribution of respondent characteristics and independent variables among the case and control groups. In addition, univariate analysis was conducted to describe the distribution of main risk factors, personal hygiene, eating habits outside the home, and level of knowledge related to typhoid fever.

Based on Table 3, it is known that the most common occupations among respondents in the typhoid fever case group were private employees, with 11 respondents (45.8%), followed by self-employed workers, with 6 respondents (25.0%). Meanwhile, the most common occupation among respondents in the control group (non-typhoid fever) was private employees, with 10 respondents (41.7%), while the least common occupation was unemployed, with 1 respondent (4.2%).

Table 4. Distribution of Cases and Controls by Personal Hygiene

Personal Hygiene	Cases (n)	Cases (%)	Controls (n)	Controls (%)	Total (n)	Total (%)
Poor (High Risk)	18	75.0	5	20.8	23	47.9
Good (Low Risk)	6	25.0	19	79.2	25	52.1
Total	24	100	24	100	48	100

Based on Table 4, it is known that out of 23 respondents (47.9%) who had poor personal hygiene, 18 respondents (75.0%) were in the case group and 5 respondents (20.8%) were in the control group. Meanwhile, out of 25 respondents (52.1%) who had good personal hygiene, 6 respondents (25.0%) were in the case group and 19 respondents (79.2%) were in the control group.

Table 5. Distribution of Cases and Controls by Eating Habits Outside the Home

Eating Habits Outside	Cases (n)	Cases (%)	Controls (n)	Controls (%)	Total (n)	Total (%)
Frequent (High Risk)	20	83.3	6	25.0	26	54.2
Infrequent (Low Risk)	4	16.7	18	75.0	22	45.8
Total	24	100	24	100	48	100

Based on Table 5, it is known that out of 26 respondents (54.2%) who had the habit of frequently eating outside the home, 20 respondents (83.3%) were in the case group and 6 respondents (25.0%) were in the control group. Meanwhile, out of 22 respondents (45.8%) who did not frequently eat outside the home, 4 respondents (16.7%) were in the case group and 18 respondents (75.0%) were in the control group.

Table 6. Distribution of Cases and Controls by Knowledge Level

Knowledge Level	Cases (n)	Cases (%)	Controls (n)	Controls (%)	Total (n)	Total (%)
Poor (High Risk)	17	70.8	6	25.0	23	47.9
Adequate (Low Risk)	7	29.2	18	75.0	25	52.1
Total	24	100	24	100	48	100

Based on Table 6, it is known that out of 23 respondents (47.9%) who had poor knowledge, 17 respondents (70.8%) were in the case group and 6 respondents (25.0%) were in the control group. Meanwhile, out of 25 respondents (52.1%) who had adequate knowledge, 7 respondents (29.2%) were in the case group and 18 respondents (75.0%) were in the control group.

Bivariate analysis

Bivariate analysis was conducted to examine the association between independent variables and the occurrence of typhoid fever using the Odds Ratio (OR) and its 95% Confidence Interval (95% CI). The analysis was based on a 2 × 2 contingency table with the statistical equation shown in (1), Standard Error (SE) in (2), and 95% Confidence Interval (CI) in (3):

$$OR = \frac{a \times d}{b \times c} \tag{1}$$

$$SE = \sqrt{\left(\frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \frac{1}{d}\right)} \tag{2}$$

$$CI = \exp[\ln(OR) \pm 1.96 \times SE] \tag{3}$$

Where a is number of cases in the exposed (high-risk) group, b is number of controls in the exposed group, c is number of cases in the unexposed (low-risk) group and d is number of controls in the unexposed group. The calculation for Table 7. Odds Ratio Calculation Based on Gender $a = 14, \quad b = 13, \quad c = 10, \quad d = 11$ is:

$$OR = \frac{14 \times 11}{13 \times 10} = \frac{154}{130} = 1.18$$
$$SE = \sqrt{\left(\frac{1}{14} + \frac{1}{13} + \frac{1}{10} + \frac{1}{11}\right)} = \sqrt{0.339} = 0.582$$
$$\text{Lower CI} = \exp[\ln(1.18) - 1.96 \times 0.582] = 0.38$$
$$\text{Upper CI} = \exp[\ln(1.18) + 1.96 \times 0.582] = 3.66$$
$$OR = 1.18 \ (95\% \, CI\text{: } 0.38\text{–}3.66)$$

The calculation for Table 8. Odds Ratio Calculation Based on Personal Hygiene $\boldsymbol{a = 18}, \quad \boldsymbol{b = 5}, \quad \boldsymbol{c = 6}, \quad \boldsymbol{d = 19}$ is:

$$OR = \frac{18 \times 19}{5 \times 6} = \frac{342}{30} = 11.40$$
$$SE = \sqrt{\left(\frac{1}{18} + \frac{1}{5} + \frac{1}{6} + \frac{1}{19}\right)} = \sqrt{0.476} = 0.689$$
$$\text{Lower CI} = \exp[\ln(11.40) - 1.96 \times 0.689] = 2.96$$
$$\text{Upper CI} = \exp[\ln(11.40) + 1.96 \times 0.689] = 43.80$$
$$OR = 11.40 \ (95\% \, CI\text{: } 2.96\text{–}43.80)$$

The calculation for Table 9. Odds Ratio Calculation Based on Eating Habits Outside the Home $\boldsymbol{a = 20}, \quad \boldsymbol{b = 6}, \quad \boldsymbol{c = 4}, \quad \boldsymbol{d = 18}$ is:

$$OR = \frac{20 \times 18}{6 \times 4} = \frac{360}{24} = 15.00$$
$$SE = \sqrt{\left(\frac{1}{20} + \frac{1}{6} + \frac{1}{4} + \frac{1}{18}\right)} = \sqrt{0.523} = 0.723$$
$$\text{Lower CI} = \exp[\ln(15.00) - 1.96 \times 0.723] = 3.64$$
$$\text{Upper CI} = \exp[\ln(15.00) + 1.96 \times 0.723] = 61.90$$
$$OR = 15.00 \ (95\% \, CI\text{: } 3.64\text{–}61.90)$$

The calculation for Table 10. Odds Ratio Calculation Based on Knowledge Level $\boldsymbol{a = 17}, \quad \boldsymbol{b = 6}, \quad \boldsymbol{c = 7}, \quad \boldsymbol{d = 18}$ is:

$$OR = \frac{17 \times 18}{6 \times 7} = \frac{306}{42} = 7.29$$

$$SE = \sqrt{\left(\frac{1}{17} + \frac{1}{6} + \frac{1}{7} + \frac{1}{18}\right)} = \sqrt{0.425} = 0.651$$

$$\text{Lower CI} = \exp[\ln(7.29) - 1.96 \times 0.651] = 2.04$$

$$\text{Upper CI} = \exp[\ln(7.29) + 1.96 \times 0.651] = 26.10$$

$$OR = 7.29\ (95\%\ CI:\ 2.04\text{–}26.10)$$

Based on Table 7, males accounted for 14 cases (58.3%) and 13 controls (54.2%), while females accounted for 10 cases (41.7%) and 11 controls (45.8%). The odds ratio analysis showed that males had a 1.185 times higher risk of developing typhoid fever compared to females (OR = 1.185; 95% CI: 0.38 - 3.66). However, since the confidence interval includes the value of 1, gender was not statistically significantly associated with the occurrence of typhoid fever.

Table 7. Risk of Typhoid Fever by Gender

Gender	**Cases n (%)**	**Controls n (%)**	**OR (95% CI)**
Male	14 (58.3)	13 (54.2)	
Female	10 (41.7)	11 (45.8)	1.18 (0.38 - 3.66)
Total	24 (100)	24 (100)	

Based on Table 8, respondents with poor personal hygiene accounted for 18 cases (75.0%) and 5 controls (20.8%), whereas those with good personal hygiene accounted for 6 cases (25.0%) and 19 controls (79.2%). The odds ratio analysis showed that respondents with poor personal hygiene had 11.40 times higher risk of developing typhoid fever compared to those with good personal hygiene (OR = 11.40; 95% CI: 2.96-43.80). This shows that personal hygiene is a significant risk factor for the occurrence of typhoid fever.

Table 8. Risk of Typhoid Fever Based on Personal Hygiene

Personal Hygiene	**Cases n (%)**	**Controls n (%)**	**OR (95% CI)**
Poor (High Risk)	18 (75.0)	5 (20.8)	
Good (Low Risk)	6 (25.0)	19 (79.2)	11.40 (2.96-43.80)
Total	24 (100)	24 (100)	

Based on Table 9, respondents who frequently ate outside the home accounted for 20 cases (83.3%) and 6 controls (25.0%), whereas respondents who infrequently ate outside the home accounted for 4 cases (16.7%) and 18 controls (75.0%). The odds ratio analysis indicated that respondents with frequent eating habits outside the home had 15.00 times higher risk of developing typhoid fever compared to those with infrequent eating habits (OR = 15.00; 95% CI: 3.64-61.90). This suggests that eating habits outside the home are a strong risk factor for typhoid fever.

Table 9. Risk of Typhoid Fever Based on Eating Habits Outside the Home

Eating Habits Outside Home	**Cases n (%)**	**Controls n (%)**	**OR (95% CI)**
Frequent (High Risk)	20 (83.3)	6 (25.0)	
Infrequent (Low Risk)	4 (16.7)	18 (75.0)	15.00 (3.64-61.90)
Total	24 (100)	24 (100)	

Based on Table 10, respondents with a poor level of knowledge accounted for 17 cases (70.8%) and 6 controls (25.0%), whereas respondents with an adequate level of knowledge accounted for 7 cases (29.2%) and 18 controls (75.0%). The odds ratio analysis showed that respondents with poor knowledge had 7.29 times higher risk of developing typhoid fever compared to those with adequate knowledge (OR = 7.29; 95% CI: 2.04-26.10). This result shows that knowledge level is a significant risk factor for typhoid fever.

Table 10. Risk of Typhoid Fever Based on Knowledge Level

Knowledge Level	Cases n (%)	Controls n (%)	OR (95% CI)
Poor (High Risk)	17 (70.8)	6 (25.0)	
Adequate (Low Risk)	7 (29.2)	18 (75.0)	7.29 (2.04-26.10)
Total	24 (100)	24 (100)	

DISCUSSION

Based on Table 7, gender was not significantly associated with the risk of typhoid fever. Although males showed a slightly higher risk compared to females (OR = 1.18; 95% CI: 0.38-3.66), the confidence interval included the value of 1, showing no statistically significant difference. This finding shows that typhoid fever affects both males and females relatively equally and that exposure to common risk factors, such as contaminated food and water, may be similar across genders in the study area (Brockett *et al*., 2020). In contrast, personal hygiene showed a strong and statistically significant association with typhoid fever occurrence. Respondents with poor personal hygiene had an 11.40-fold higher risk of developing typhoid fever compared to those with good personal hygiene (95% CI: 2.96-43.80). This markedly high odds ratio shows that inadequate hygiene practices play a critical role in facilitating fecal oral transmission of *Salmonella typhi*, particularly through insufficient handwashing with soap after defecation and before eating or food preparation. In semi-urban areas such as Delanggu, this condition may be exacerbated by limited access to clean water, inconsistent availability of handwashing facilities, and low adoption of handwashing with soap (CTPS) as a routine cultural practice. These factors likely amplify the impact of poor personal hygiene on typhoid fever transmission in the community (Ehuwa *et al*., 2021).

Eating habits outside the home were identified as the strongest risk factor for typhoid fever in this study. Respondents who frequently ate outside the home had a 15.00 times higher risk of developing typhoid fever compared to those who ate outside infrequently (95% CI: 3.64-61.90). The very high odds ratio suggests substantial exposure to unsafe food environments, particularly food vending places (Tempat Pengelolaan Makanan/TPM) with suboptimal sanitation standards. In semi-urban settings, rapid growth of informal food vendors is often not accompanied by adequate hygiene supervision, safe water supply, or proper waste management. Poor food handling practices, use of contaminated water, and inadequate hand hygiene among food handlers may significantly increase the likelihood of food contamination and subsequent typhoid transmission (Nahiduzzaman *et al*., 2025). Therefore, eating outside the home in this should be interpreted not merely as a behavioral factor, but as a proxy for environmental sanitation risks surrounding food preparation sites.

Then, knowledge level was significantly associated with typhoid fever occurrence. Respondents with poor knowledge had a 7.29 times higher risk of developing typhoid fever compared to those with adequate knowledge (95% CI: 2.04-26.10). This finding aligns with health behavior theories, suggesting that limited understanding of disease transmission, preventive measures, and personal hygiene practices may lead to underestimation of risk and inadequate adoption of protective behaviors. Poor knowledge may also delay appropriate health-seeking behavior, increasing the likelihood of disease progression and transmission within households and communities.

This study employed bivariate analysis, which limits the ability to identify the most dominant risk factor after controlling for potential confounding variables. Given the high odds ratios observed for eating habits outside the home and personal hygiene, future studies are strongly encouraged to apply multivariate logistic regression analysis to determine the independent effect of each variable and to strengthen causal inference. Such analysis would provide more robust evidence for prioritizing public health interventions in semi-urban settings.

CONCLUSION AND RECOMMENDATION

This study shows that gender is not a significant determinant of typhoid fever occurrence, that males and females are equally vulnerable when exposed to similar environmental and behavioral risk factors. In contrast, poor personal hygiene, frequent eating outside the home, and inadequate knowledge were identified as significant risk factors that substantially increased the likelihood of typhoid fever. The prevention efforts should prioritize improving personal hygiene practices, strengthening food safety and sanitation standards in public eating places, and enhancing community knowledge regarding typhoid fever transmission and prevention. Public health programs should concern on sustained health education, promotion of proper handwashing behavior, and regular monitoring of food vendors to reduce contamination risks.

DAFTAR PUSTAKA

Aiemjoy, K., Seidman, J. C., Saha, S., Munira, S. J., Sajib, M. S. I., Al Sium, S. M., & Andrews, J. R. (2022). Estimating typhoid incidence from community-based serosurveys: a multicohort study. *The Lancet Microbe*, *3*(8), e578-e587.

Bisola Bello, A., Olamilekan Adesola, R., Idris, I., Yawson Scott, G., Alfa, S., & Akinfemi Ajibade, F. (2024). Combatting extensively drug-resistant Salmonella: a global perspective on outbreaks, impacts, and control strategies. *Pathogens and global health*, *118*(7-8), 559-573.

Boakye Okyere, P., Twumasi-Ankrah, S., Newton, S., Nkansah Darko, S., Owusu Ansah, M., Darko, E., & Owusu-Dabo, E. (2025). Risk Factors for Typhoid Fever: Systematic Review. *JMIR Public Health and Surveillance*, *11*, e67544.

Brockett, S., Wolfe, M. K., Hamot, A., Appiah, G. D., Mintz, E. D., & 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), 1020.

Castillo, F., Mora, A. M., Kayser, G. L., Vanos, J., Hyland, C., Yang, A. R., & Eskenazi, B. (2021). Environmental health threats to Latino migrant farmworkers. *Annual Review of Public Health*, *42*(1), 257-276.

da Silva, K. E., Tanmoy, A. M., Pragasam, A. K., Iqbal, J., Sajib, M. S. I., Mutreja, A., & Andrews, J. R. (2022). The international and intercontinental spread and expansion of antimicrobial-resistant Salmonella Typhi: a genomic epidemiology study. *The Lancet Microbe*, *3*(8), e567-e577.

Ehuwa, O., Jaiswal, A. K., & Jaiswal, S. (2021). Salmonella, food safety and food handling practices. *Foods*, *10*(5), 907.

Gashaw, T., & Jambo, A. (2022). Typhoid in less developed countries: a major public health concern. In *Hygiene and Health in Developing Countries-Recent Advances*. IntechOpen.

Gething, P. W., Ayling, S., Mugabi, J., Muximpua, O. D., Kagulura, S. S., & Joseph, G. (2023). Cholera risk in Lusaka: A geospatial analysis to inform improved water and sanitation provision. *PLoS Water*, *2*(8), e0000163.

Kim, C. L., Cruz Espinoza, L. M., Vannice, K. S., Tadesse, B. T., Owusu-Dabo, E., Rakotozandrindrainy, R., & Marks, F. (2022). The burden of typhoid fever in sub-Saharan Africa: a perspective. *Research and reports in tropical medicine*, 1-9.

Kim, C., Goucher, G. R., Tadesse, B. T., Lee, W., Abbas, K., & Kim, J. H. (2023). Associations of water, sanitation, and hygiene with typhoid fever in case–control studies: a systematic review and meta-analysis. *BMC infectious diseases*, *23*(1), 562.

Liu, Y., Du, X., Chen, J., Jin, Y., Peng, L., Wang, H. H., & Zhao, Y. (2020). Neutrophil-to-lymphocyte ratio as an independent risk factor for mortality in hospitalized patients with COVID-19. *Journal of Infection*, *81*(1), e6-e12.

Ma, L., Liu, H., Tao, Z., Jiang, N., Wang, S., & Jiang, X. (2020). Knowledge, Beliefs/Attitudes, and practices of rural residents in the prevention and control of COVID-19: an online questionnaire survey. *The American journal of tropical medicine and hygiene*, *103*(6), 2357.

Maphosa, M., & Moyo, P. (2025). Urban governance and its role in shaping low-income household food security in Bulawayo, Zimbabwe. *Frontiers in Sustainable Cities*, *7*, 1700872.

Muche, G., Tesfaw, A., & Bayou, F. D. (2024). Prevalence of typhoid fever and its associated factors among febrile patients visiting Arerti Primary Hospital, Amhara Region, north east Ethiopia. *Frontiers in Public Health*, *12*, 1357131.

Nahiduzzaman, F. N. U., Zarin, T., Chouhan, C. S., Rahman, M. Z., Khatun, M. M., Rahman, A. A., & Haque, M. A. (2025). Health effects of street vended fresh cut fruits: A randomized controlled trial in Bangladesh. *PLoS One*, *20*(10), e0335979.

Nakisuyi, J., Bernis, M., Ndamira, A., Kayini, V., Mulumba, R., Theophilus, P., & Lule, H. (2023). Prevalence and factors associated with malaria, typhoid, and co-infection among febrile children aged six months to twelve years at kampala international university teaching hospital in western Uganda. *Heliyon*, *9*(9).

Nampota-Nkomba, N., Carey, M. E., Jamka, L. P., Fecteau, N., & Neuzil, K. M. (2023). Using typhoid conjugate vaccines to prevent disease, promote health equity, and counter drug-resistant typhoid fever. In *Open Forum Infectious Diseases* (Vol. 10, No. Supplement_1, pp. S6-S12). US: Oxford University Press.

Natour, N. O. A., Alshawish, E., & Alawi, L. (2023). Role of health belief model and health consciousness in explaining behavioral intention to use restaurants and practicing healthy diet. *Nutrition & Food Science*, *53*(6), 977-985.

Ren, X., Zhang, S., Luo, P., Zhao, J., Kuang, W., Ni, H., & Lv, Y. (2023). Spatial heterogeneity of socio-economic determinants of typhoid/paratyphoid fever in one province in central China from 2015 to 2019. *BMC Public Health*, *23*(1), 927.

Salamandane, A., Malfeito-Ferreira, M., & Brito, L. (2023). The socioeconomic factors of street food vending in developing countries and its implications for public health: a systematic review. *Foods*, *12*(20), 3774.

Sawyer, W. E., Ovuru, K. F., Etim, N. G., & El-Liethy, M. A. (2025). Water Quality Management: Processes Influencing Waterborne Diseases and Sustainable Solutions. In *Innovative Approaches in Environmental Health Management: Processes, Technologies, and Strategies for a Sustainable Future* (pp. 53-85). Cham: Springer Nature Switzerland.

Soboksa, N. E. (2022). Environmental and behavioral factors associated with handwashing with soap after defecation in a rural setting of 2 districts of the Jimma Zone, Ethiopia. *Environmental Health Insights*, *16*, 11786302221091421.

Thalia, O. P. (2024). Understanding the Risk Factors and Vulnerable Populations in the Spread of Diarrhea and Typhoid Fever: Socioeconomic Influences, Malnutrition and Susceptibility among risk Groups. *Idsor Journal of Applied Sciences*, *9*(3), 1-6.

Turgut, A. O., & Koca, D. (2024). The effects of case/control ratio and sample size on genome-wide association studies: A simulation study. *Veterinary Medicine and Science*, *10*(3), e1444.

Wittenberg, G. M., Greene, J., Vértes, P. E., Drevets, W. C., & Bullmore, E. T. (2020). Major depressive disorder is associated with differential expression of innate immune and neutrophil-related gene networks in peripheral blood: a quantitative review of whole-genome transcriptional data from case-control studies. *Biological psychiatry*, *88*(8), 625-637.