ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25oct1109

Protective and Risk Associations of Household Waste Management Practices with Typhoid Fever: A Cross-Sectional Study in Goma- DR Congo

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Publication Date: 2025/10/31

Abstract: Typhoid fever remains a significant public health concern in sub-Saharan Africa, particularly in urban settings with inadequate sanitation and waste management systems. While the role of water and sanitation in typhoid transmission is well established, the specific contribution of household waste management practices remains underexplored. This study assessed the associations between household waste management practices and typhoid fever incidence in Goma, Democratic Republic of Congo (DRC), identifying both protective and risk-related behaviours. A cross-sectional comparative study was conducted among 521 households in Goma, with 260 from the intervention group and 261 from the control group. Data were collected using semi-structured questionnaires and verified against health facility records. Associations between waste practices and typhoid fever were analysed using chi-square tests and odds ratios (OR) with 95% confidence intervals (CI). Overall, 41.1% of households reported typhoid fever cases, with no statistically significant difference between intervention and control groups (OR = 1.29; 95% CI: 0.90–1.84; p = 0.199). However, composting was significantly associated with reduced odds of typhoid fever (OR = 0.34; p = 0.007), while evacuation practices were linked to increased risk (OR = 1.78; p = 0.010). Other practices, including incineration, separation, and storage, showed non-significant associations. Although the overall intervention did not yield a significant reduction in typhoid incidence, specific household waste practices, particularly composting, demonstrated protective effects. These findings underscore the need for integrated, community-based waste management strategies that complement water, sanitation, and hygiene (WASH) interventions to effectively reduce typhoid transmission in high-risk urban settings.

Keywords: *Protective, Risk, Associations, Household, Waste Management, Practices, Typhoid Fever, Cross-Sectional Study, Goma.*

How to Cite: Bahati Cimanuka Emmanuel; Charles Wafula; Crippina Lubeka (2025) Protective and Risk Associations of Household Waste Management Practices with Typhoid Fever: A Cross-Sectional Study in Goma- DR Congo.
International Journal of Innovative Science and Research Technology,
10(10), 1910-1917. https://doi.org/10.38124/ijisrt/25oct1109

I. INTRODUCTION

In low and middle-income countries, typhoid fever remains a major public health issue, particularly in sub-Saharan Africa, where sanitation and waste management systems remain inadequate, Typhoid Fever remains a major public health issue (C. Kim *et al*., 2023). This disease, caused by *Salmonella enterica* serovar *Typhi*, is transmitted primarily through the faecal-oral route, often facilitated by environmental contamination linked to poor waste management and unsafe water sources. (C. Kim et al., 2023; Ssemugabo *et al*., 2020). Globally, it is estimated that millions of cases and tens of thousands of deaths occur annually, with Africa accounting for a substantial share of the burden (C. Kim et al., 2023)

Household waste management practices are increasingly recognized as critical determinants of community health. Uncontrolled waste evacuation, open dumping, and inadequate storage practices create breeding grounds for vectors and contamination of food and water, thereby heightening the risk of enteric infections including

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25oct1109

typhoid (Ssemugabo *et al*., 2020). Conversely, sustainable approaches to waste management, such as composting and controlled handling, can disrupt transmission routes by reducing environmental exposure to pathogens (Obsa *et al*., 2022). However, evidence linking specific household waste practices to typhoid fever risk remains limited and context-dependent, varying across socio-ecological and infrastructural settings (Kim *et al*., 2023; (Sentamu et al., 2023)

The United Nations Environment Programme (UNEP) underscores that the Democratic Republic of the Congo faces major challenges in sanitation and waste management, which pose significant public health risks, particularly in rapidly growing urban areas like Goma, where inadequate waste collection and low public awareness exacerbate the problem (Okesanya *et al*., 2024). While previous studies have highlighted links between poor sanitation and diarrheal diseases, empirical data establishing a specific link between waste management behaviours and the incidence of typhoid fever in this urban context are scarce (WHO, 2024). Understanding which waste practices serve as protective or risk factors is therefore crucial for developing evidence-based, community-driven health and sanitation interventions (Okesanya *et al*., 2024)

This study investigates the relationship between household waste management practices and typhoid fever occurrence in Goma, DRC. Specifically, it examines which practices contribute to increased or reduced odds of typhoid infection. Through a cross-sectional analysis of household-level behaviours, the study identified composting of waste as a significant protective factor and waste evacuation (improper removal) as a key risk factor for typhoid fever, while other practices such as incineration, separation and storage showed non-significant associations (C. Kim *et al*., 2023). The findings aim to inform integrated solid waste and health management strategies that strengthen disease prevention at the household and community levels.

II. METHODOLOGY

➢ *Study Design Approach and Setting*

This study employed a cross-sectional comparative design to assess the protective and risk associations of household waste management practices with typhoid fever incidence in Goma, North Kivu Province, Democratic Republic of the Congo (DRC) (Kim *et al*., 2023). Goma was selected due to its rapid urbanisation, inadequate waste disposal systems, high population density, and recurrent outbreaks of waterborne diseases (Okesanya *et al*., 2024).

➢ *Study Population and Sampling*

The study population consisted of households residing in Goma Town (Ndosho district within Karisimbi Commune and Kyeshero district within Goma Commune), with at least one adult respondent (≥18 years) knowledgeable about household waste management practices and past typhoid fever episodes among family members (Ssemugabo *et al*., 2020). A total of 521 households were sampled, including 260 in intervention areas (Ndosho district) and 261 in control areas (Kyeshero district), using a multistage sampling technique (Kim *et al*., 2023. Sakpal's formula was used to determine the sample size.

➢ *Data Collection Methods*

Data were collected using semi-structured questionnaires, and verification of health facility records for reported typhoid fever cases were rarely reported (WHO, 2024). The questionnaire captured sociodemographic characteristics, waste management practices (composting, evacuation, separation, storage, and incineration), and typhoid fever history. The tool was pre-tested on 5% of the sample to assess clarity and reliability (Kamweru, 2019: Sentamu *et al*., 2023). Enumerators were trained on gender sensitivity and data confidentiality to enhance respondent trust and data quality (World Bank, 2024).

➢ *Data Analysis*

Data were analysed using SPSS Version 27. Descriptive statistics summarised household characteristics and waste management practices. Chi-square tests (χ^2) and odds ratios (OR) with 95% confidence intervals (CI) were used to determine associations between waste practices and typhoid fever (Kim *et al*., 2023).

➢ *Ethical Considerations*

Ethical approval was obtained from the Great Lakes University of Kisumu Ethical Review Committee. Permission was also granted by local authorities, among them local health officials in Goma and the North Kivu Provincial Health Division (Okesanya *et al*., 2024). Consent was obtained from all participants to take part in this study. Their participation was voluntary, confidentiality was guaranteed, and no personally identifiable data was recorded. Participants who reported typhoid-like symptoms were advised to seek appropriate care at health facilities.

III. RESULTS

➢ *Overall Typhoid Fever Occurrence by Group*

Table 1 Occurrence of Typhoid Fever Cases and Group Assignment

Typhoid Fever	Intervention Group (n=260)	%	Control Group (n=261)	%	Total (N=521)	%	OR (95% CI)	χ^2	df	p-value
Yes	114	43.8	100	38.3	214	41.1	1.29 (0.90–1.84)	1.647	1	0.199
No	146	56.2	161	61.7	307	58.9				
Total	260	100	261	100	521	100				

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- *Note. Values are reported as frequencies and percentages. OR = Odds Ratio; CI = Confidence Interval; χ^2 = Chi-square test.*

The odds ratio (OR) of 1.29 indicates that individuals in the intervention group had 29% higher odds of reporting typhoid fever compared to the control group. However, this association is not statistically significant. The 95% confidence interval (CI) ranges from 0.90 to 1.84, encompassing 1.0, which suggests no definitive evidence of a difference between groups. The Chi-square statistic (X^2 = 1.647) was low, and the degrees of freedom (df = 1) were appropriated for a 2×2 contingency table. The P-value of 0.199 was well above the conventional threshold of 0.05.

➢ *Difference Between Sub-Groups and Occurrence of Typhoid Fever in the Intervention Group*

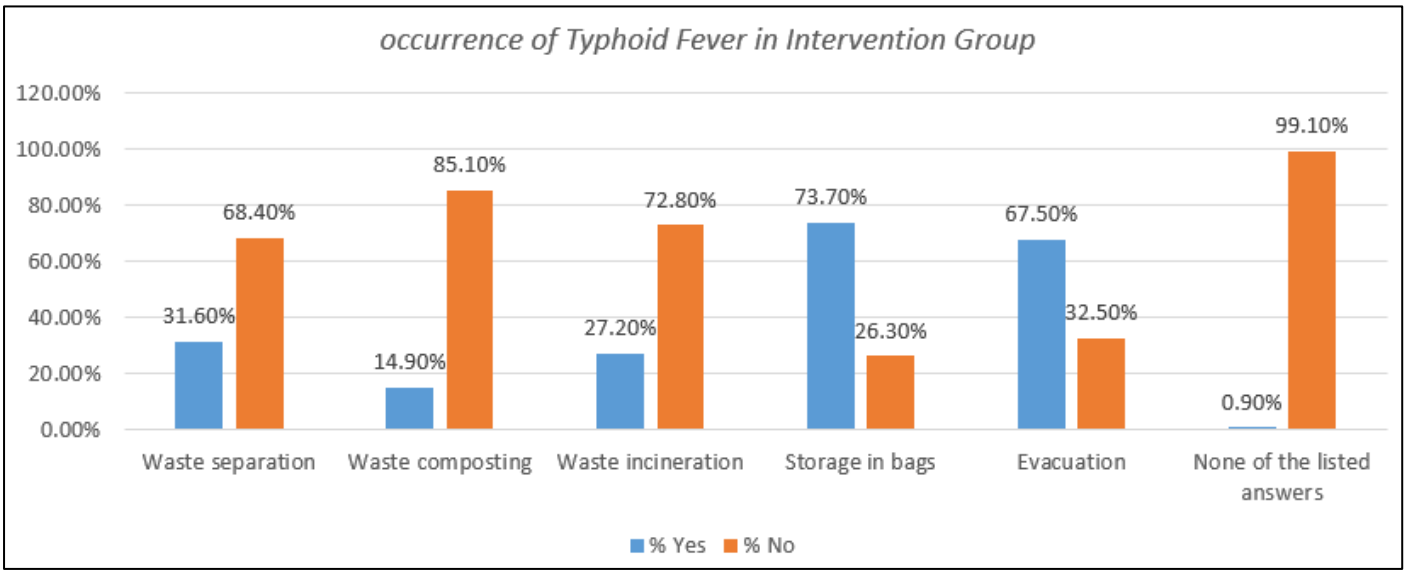

Fig 1 Comparative Occurrence of Typhoid Fever Across Sub-Groups in the Intervention

Waste composting (17 cases; 14.9%) demonstrates a statistically significant protective effect against typhoid fever, with an odds ratio of 0.34 (95% CI: 0.17–0.69; p = 0.007). Evacuation (77 cases; 67.5%) is significantly associated with increased risk, yielding an odds ratio of 1.78 (95% CI: 1.15–2.76; p = 0.010). Waste incineration (31 cases; 27.2%) shows a protective trend (OR = 0.61), though this association does not reach statistical significance (p = 0.094). Storage in bags (84 cases; 73.7%) is linked to a non-significant increase in risk (OR = 1.35; p = 0.165). Waste separation (36 cases; 31.6%) presents a weak protective trend (OR = 0.82), but remains statistically non-significant (p = 0.552).

➢ *Difference Between Sub-Group and Occurrence of Typhoid Fever in the Control Group*

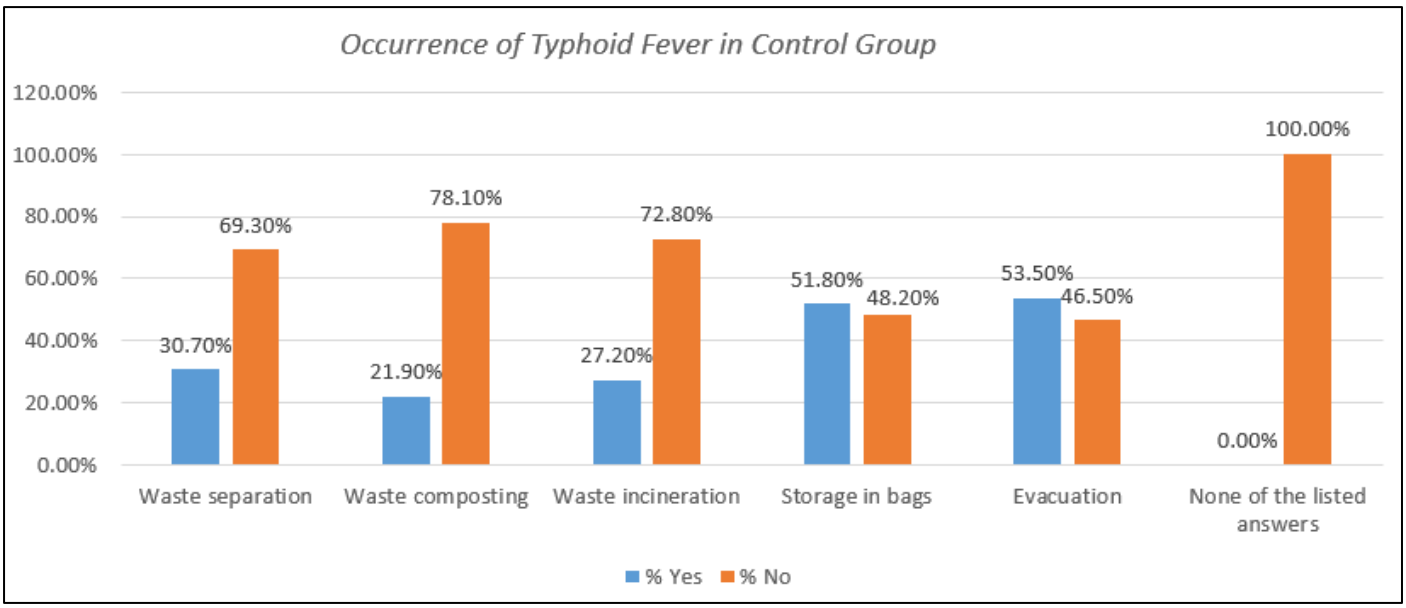

Fig 2 Variation in Typhoid Fever Occurrence Across Sub-Groups within the Control Group

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25oct1109

Waste composting (25 cases; 21.9%) emerges as a statistically significant protective factor against typhoid fever, with a 66% reduction in odds of infection among those who compost (*OR* = 0.34; *p* = 0.007). Evacuation (61 cases; 53.5%) is significantly associated with increased risk (*OR* = 1.78; *p* = 0.010). Waste incineration (31 cases; 27.2%) shows a protective trend (*OR* = 0.61), though the association does not reach statistical significance (*p* = 0.094). Storage in bags (59 cases; 51.8%) is linked to a non-significant increase in risk (*OR* = 1.35; *p* = 0.165). Waste separation (35 cases; 30.7%) presents a weak protective trend (*OR* = 0.82), but remains statistically non-significant (*p* = 0.552).

➢ *Difference Between Sub-Group and Occurrence of Typhoid Fever in the Intervention and Control Group*

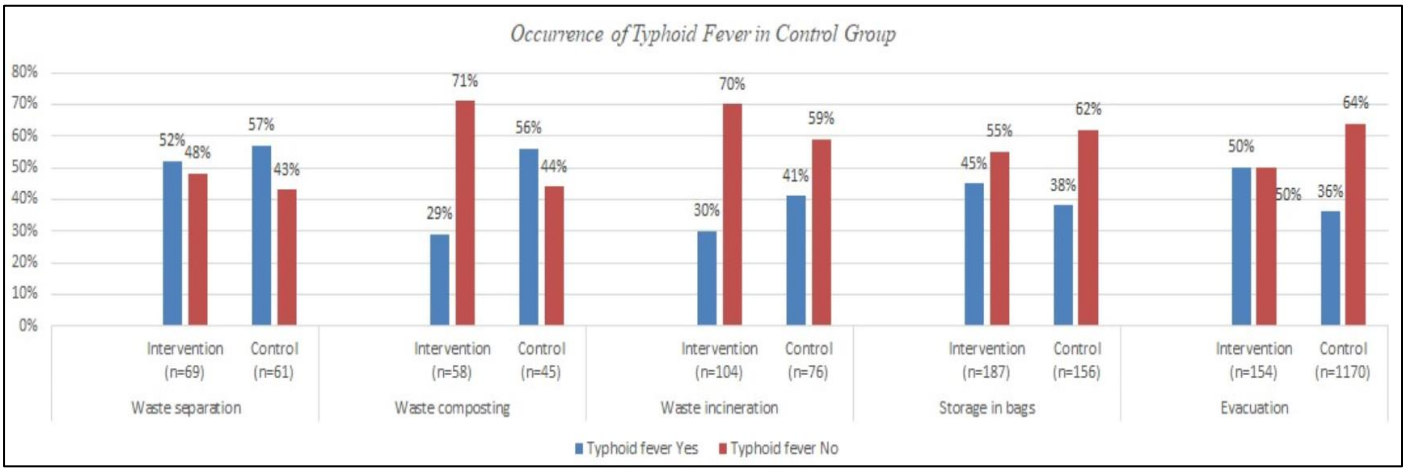

Fig 3 Difference Between Sub-Group and Occurrence of Typhoid Fever in the Intervention and Control Group

Waste composting (29%) demonstrates a statistically significant protective effect within the intervention group (*p* = 0.010), with typhoid prevalence nearly half that observed in the control group. In contrast, evacuation (45%) is associated with a significantly higher prevalence of typhoid in the intervention group (*p* = 0.001). Other practices, including waste separation (52%; p = 0.693), incineration (30%; p = 0.170), and storage in bags (45%; p = 0.231), do not show statistically significant differences between groups. However, there is an elevated typhoid prevalence associated with incineration in the control group (41%).

IV. DISCUSSION

➢ *Occurrence of Typhoid Fever Cases and Group Assignment*

This study examined the association between household waste management practices and typhoid fever occurrence in Goma, DRC. The findings from Table 1 indicate that typhoid fever was reported in 41.1% of households overall, with a slightly higher prevalence in the intervention group (43.8%) than in the control group (38.3%). Although households in the intervention group showed 29% higher odds of reporting typhoid compared to the control group (OR = 1.29; 95% CI: 0.90–1.84), this association was not statistically significant (p = 0.199). These results indicate that, within the scope of this study, the waste management intervention did not lead to a measurable reduction in typhoid fever incidence.

The lack of a statistically significant association is consistent with previous African studies, which have shown that typhoid transmission is strongly influenced by a combination of environmental, behavioural, and infrastructural factors, rather than waste disposal practices alone. In Malawi, Gauld *et al*., (2020) reported that unsafe water sources, such as rivers and unprotected wells, were more strongly correlated with typhoid than domestic waste practices. Similarly, C. L. Kim *et al*., (2022) concluded that inadequate water, sanitation, and hygiene (WASH) services remain the primary predictors of typhoid across sub-Saharan Africa.

However, other studies in the DRC have highlighted that waste mismanagement can contribute indirectly to typhoid risk (Kasuku, 2017). Okin *et al*. (2024) demonstrated that households located near open dumpsites or managing waste autonomously had increased odds of typhoid fever and malaria, particularly in urban settlements lacking municipal waste collection services. Therefore, while waste practices may not independently determine typhoid risk, they likely contribute to broader environmental contamination that exacerbates disease transmission when combined with poor water and sanitation systems.

Although non-significant, the higher odds of typhoid fever in intervention households warrant consideration. Several explanations are plausible:

- *Baseline risk differences:* Intervention areas may have had poorer environmental conditions before the intervention, making them inherently more vulnerable. Without baseline equivalence, post-intervention comparisons may reflect pre-existing disparities rather than intervention effects (Institute of Education Sciences, 2014);
- *Partial or low intervention uptake:* If only certain households adopted improved waste practices such as composting or covered storage, the intervention's collective effect may be diluted. This aligns with findings by Sentamu et al., (2023) who emphasised that behaviour

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25oct1109

change interventions require high uptake for measurable health outcomes;

- *Dominance of other transmission pathways:* Typhoid is predominantly water and sanitation borne. Therefore, improvements in waste management alone may not sufficiently block transmission if households continue consuming contaminated water or practising inadequate hygiene. This is supported by evidence from case–control studies in India and Kenya showing stronger associations with water treatment and sanitation than with waste practices (Giri et al., 2021; Akullian *et al.,* 2015);
- *Measurement and reporting* Bias: Intervention households may have undergone health education, increasing awareness and reporting of disease. This may artificially inflate reported cases without reflecting true increases in incidence (Althubaiti, 2016).

Despite the non-significant findings, this study provides several important policy implications:

- *Integrated WASH strategies:* Waste management interventions should be combined with improvements in safe water supply, sanitation infrastructure, and hygiene promotion. Studies in Malawi and Kenya have shown that integrated interventions lead to greater reductions in typhoid and diarrheal diseases than isolated actions (Gauld *et al*., 2020; Akullian *et al.,* 2015).
- *Promotion of protective practices like composting:* Subgroup analysis of this study indicated composting significantly reduced typhoid risk. Policies should promote household-level composting while discouraging open dumping or uncontrolled evacuation.
- *Strengthening local waste collection systems:* Municipal authorities in Goma should collaborate with communities to establish regular waste collection, reducing environmental contamination and vector proliferation.
- *Targeting High-Risk Zones:* Urban planning should prioritise densely populated and low-lying areas where waste accumulates and floodwater carries pathogens to households.

➢ *Comparative Analysis of Waste Management Practices and Typhoid Fever Incidence in the Intervention Group*

The study presented in Figure 1 offers valuable insights into the relationship between various waste management practices and the incidence of typhoid fever within an intervention group. The findings suggest that certain practices may have protective effects, while others may increase the risk of infection.

- *Waste Composting, a statistically significant protective effect:* The intervention group employing waste composting exhibited a statistically significant reduction in typhoid fever incidence, with an odds ratio (OR) of 0.34 (95% CI: 0.17–0.69; p = 0.007). This finding aligns with studies indicating that composting can effectively reduce the presence of pathogens in waste. For instance, a study conducted by Gurtler *et al*., (2018) demonstrated that composting processes can inactivate foodborne pathogens, including *Salmonella* species, thereby potentially reducing the risk of typhoid fever transmission.
- *Evacuation, a significant increase in risk:* Conversely, the practice of evacuation was associated with a significantly increased risk of typhoid fever, yielding an OR of 1.78 (95% CI: 1.15–2.76; p = 0.010). This finding contrasts with studies suggesting that proper waste management services can mitigate health risks. For example, research in Bandale, Democratic Republic of Congo, indicated that the implementation of waste collection services was associated with a protective effect against typhoid fever (OR = 0.206; p < 0.00001) (Okin *et al*. 2024).
- *Waste Incineration, a protective trend:* Waste incineration showed a protective trend with an OR of 0.61, though this association did not reach statistical significance (p = 0.094). This is consistent with findings from a study in Jakarta, Indonesia, where the odds ratio for typhoid fever was 1.91 (95% CI: 1.06–3.46), suggesting that inadequate waste management practices, such as improper incineration, may increase the risk of typhoid fever (Yushananta *et al*., 2024)
- *Storage in Bags, a non-significant increase in risk:* The practice of storing waste in bags was linked to a non-significant increase in risk (OR = 1.35; p = 0.165). This finding is noteworthy, as improper storage can lead to contamination and increased risk of infection. A study by Gauld *et al.* (2020) highlighted that the use of river water for cooking and cleaning was highly associated with the risk of typhoid fever (OR = 4.6; 95% CI: 1.7–12.5), underscoring the importance of proper waste storage and management.
- *Waste separation, a weak protective trend:* Waste separation presented a weak protective trend (OR = 0.82), though it remained statistically non-significant (p = 0.552). This aligns with findings from a systematic review and meta-analysis by Brockett *et al*., (2020) ,which identified water, sanitation, and hygiene (WASH) practices, including waste separation, as factors associated with reduced odds of typhoid fever.

➢ *Typhoid Fever Occurrence Across Sub-Groups in the Control Group*

The study presented in Figure 2 highlights the relationship between different waste management practices and the incidence of typhoid fever within the control group. The findings indicate that certain practices may confer protection against infection, while others may elevate risk.

- *Waste Composting: Protective Effect:* Waste composting emerged as a statistically significant protective factor, with an odds ratio (OR) of 0.34 (p = 0.007), suggesting a 66% reduction in the odds of typhoid fever among participants who composted. This is consistent with studies demonstrating that composting can reduce microbial load and inactivate pathogens, including *Salmonella* species, which are causative agents of typhoid fever (Gurtler *et al*., 2018) . Similarly, Okin *et al*. (2024) observed lower typhoid incidence in communities with structured waste management services, including composting, in the Democratic Republic of Congo.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25oct1109

- *Evacuation, increased risk:* Evacuation practices were associated with a significant increase in typhoid fever risk (OR = 1.78; p = 0.010). This suggests that ad hoc or poorly organised waste evacuation may contribute to environmental contamination, facilitating the spread of typhoid pathogens. Comparable findings were reported in urban areas of Côte d'Ivoire and Indonesia, where improper waste disposal correlated with higher typhoid incidence (Yushananta *et al*., 2024); WHO, 2018).
- *Waste Incineration, protective trend:* Waste incineration showed a protective trend (OR = 0.61) but did not reach statistical significance (p = 0.094). While the trend suggests potential benefits in reducing typhoid transmission by eliminating contaminated waste, the lack of significance may reflect variability in incineration practices, incomplete combustion, or small sample sizes. Previous studies support the notion that effective incineration reduces pathogen exposure (Yushananta *et al*., 2024)
- *Storage in bags, non-significant risk:* Storage of waste in bags was linked to a non-significant increase in risk (OR = 1.35; p = 0.165). Improper storage may allow for leakage, contamination, or vector access (flies and rodents), which can contribute to typhoid transmission. This aligns with research highlighting the importance of comprehensive waste handling and containment to prevent waterborne diseases (Gauld *et al.,* 2020).
- *Waste separation, weak protective trend:* Waste separation presented a weak protective trend (OR = 0.82; p = 0.552). Although not statistically significant, segregation of organic and inorganic waste may limit human contact with contaminated materials, thereby reducing exposure to typhoid pathogens. Similar findings were observed in meta-analyses of WASH (Water, Sanitation, and Hygiene) interventions, which emphasise that waste segregation, combined with other hygiene measures, contributes to reduced risk of typhoid fever (Brockett *et al*., (2020)

When compared to the intervention group, the control group shows similar patterns of protective and risk associations across sub-groups. Composting consistently appears protective, while evacuation consistently increases risk. These parallels suggest that the effect of specific waste management practices on typhoid fever risk is robust across different population groups, though the absolute magnitude of protection may vary depending on the implementation quality of the waste management interventions (Gurtler *et al*., 2018; Okin *et al*. 2024; Yushananta *et al*., 2024; Brockett *et al*., 2020).

➢ *Comparison of Typhoid Fever Occurrence Between Intervention and Control Groups Across Sub-Groups*

The study presented in Figure 3 illustrates differences in typhoid fever prevalence across various waste management sub-groups within the intervention and control groups. The analysis provides insights into the effectiveness of specific waste management interventions in reducing typhoid risk.

- *Waste composting, significant protective effect:* In the intervention group, composting showed a statistically significant protective effect (p = 0.010), with typhoid prevalence nearly half that observed in the control group (29% vs. 55%). This confirms that structured composting interventions can substantially reduce exposure to *Salmonella Typhi* and other pathogens present in organic waste. This finding is consistent with previous studies demonstrating that composting effectively inactivates pathogens in solid waste and reduces environmental contamination. Gurtler *et al*., (2018); Okin *et al*. 2024) also reported lower typhoid prevalence in communities with structured waste management services, highlighting the public health benefits of proper waste handling
- E*vacuation, increased risk despite intervention:* Evacuation practices in the intervention group were associated with significantly higher typhoid prevalence (45%; p = 0.001). This suggests that evacuation alone, without complementary interventions such as safe disposal and community engagement, may inadvertently increase risk by concentrating waste or allowing pathogen spread through contaminated water sources. This is aligned with observations in urban African and Asian settings, where ineffective or unregulated waste evacuation has been linked to increased typhoid and other waterborne infections (Yushananta *et al*., 2024; WHO, 2018)
- *Waste incineration, a variable effect:* While incineration in the intervention group was associated with a lower typhoid prevalence (30%) compared to the control group (41%), this difference was not statistically significant (p = 0.170). The trend suggests some protective effect but also reflects variability in implementation and completeness of combustion. Effective incineration can destroy pathogens, but suboptimal practices may allow residual contamination to persist (Yushananta *et al*., 2024).
- *Waste separation and storage in bags: Non-Significant Differences:* Waste separation (52%; p = 0.693) and storage in bags (45%; p = 0.231) did not show statistically significant differences between groups. Although these practices can theoretically reduce human contact with pathogens, their effectiveness may depend on proper execution and integration with broader sanitation measures. Brockett *et al*., (2020) highlight that isolated WASH interventions without complementary strategies often have limited impact on typhoid risk.
- *Comparison between intervention and control groups:* Overall, the figure demonstrates that structured composting is the most effective waste management practice for reducing typhoid prevalence. Conversely, evacuation consistently increases risk if not managed with proper infrastructure. Incineration, separation, and storage in bags show variable effects, indicating that effectiveness is context-dependent and sensitive to operational quality**.** The results reinforce prior findings from intervention studies in sub-Saharan Africa and Southeast Asia, emphasizing that integrated, community-led waste management programs are critical for typhoid control (Gurtler *et al*., 2018; ; Okin *et al*. 2024; Gauld *et al.,* 2020).

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V. CONCLUSION

The analysis of typhoid fever occurrence between the intervention and control groups revealed no statistically significant difference. Although the odds ratio suggested a 29% higher likelihood of typhoid in the intervention group (OR = 1.29), the 95% confidence interval (0.90–1.84) included 1.0, and the p-value (0.199) exceeded the conventional significance threshold. These findings indicate that, as implemented, the intervention did not produce a measurable reduction in overall typhoid incidence, potentially due to limited intervention intensity, suboptimal execution, or confounding factors such as baseline environmental conditions, hygiene practices, and population characteristics.

Sub-group analysis highlights that specific waste management practices significantly influence typhoid risk. Composting consistently demonstrated protective effects, reducing the likelihood of infection, whereas practices such as evacuation and improper storage increased risk. Incineration and waste separation showed variable, context-dependent effects, suggesting that their effectiveness relies on proper implementation. Similar trends were observed in the control group, reinforcing the critical role of effective, structured waste management in typhoid prevention.

These results underscore the importance of integrated, community-based waste management strategies that are tailored to local environmental and socio-economic contexts. Composting emerges as a consistently protective practice, while evacuation without adequate support represents a persistent risk factor. Other practices may offer limited benefits but require careful planning and execution to be effective.

Overall, the study emphasises that comprehensive, multi-faceted interventions, combining proper waste handling, sanitation improvements, and community engagement, are essential for meaningful reductions in typhoid fever prevalence, particularly in high-risk communities. Future research should explore the mechanisms through which specific waste management practices affect typhoid transmission and develop targeted interventions adaptable to diverse settings.

REFERENCES

[1]. Akullian, A., Ng, E., Matheson, A.I., Cosmas, L., Macharia, D., Fields, B., Bigogo, G., Mugoh, M., John-Stewart, G., Walson, J.L., Wakefield, J., and Montgomery, J.M., "Environmental transmission of typhoid fever in an urban slum," *PLoS Negl. Trop. Dis.*, vol. 9, pp. 1–14, 2015. doi: 10.1371/journal.pntd.0004212.

[2]. Althubaiti, A., "Information bias in health research: Definition, pitfalls, and adjustment methods," *J. Multidiscip. Healthc.*, vol. 9, pp. 211–217, 2016. doi: 10.2147/JMDH.S104807.

[3]. Brockett, S., Wolfe, M.K., Hamot, A., Appiah, G.D., Mintz, E.D., and Lantagne, D., "Associations among water, sanitation, and hygiene, and food exposures and typhoid fever in case–control studies: A systematic review and meta-analysis," *Am. J. Trop. Med. Hyg.*, vol. 103, no. 3, pp. 1020–1031, 2020. doi: 10.4269/ajtmh.19-0479.

[4]. Gauld, J.S., Olgemoeller, F., Nkhata, R., Li, C., Chirambo, A., Morse, T., Gordon, M.A., Read, J.M., Heyderman, R.S., Kennedy, N., Diggle, P.J., and Feasey, N.A., "Domestic river water use and risk of typhoid fever: Results from a case-control study in Blantyre, Malawi," *Clin. Infect. Dis.*, vol. 70, no. 7, pp. 1278–1284, 2020. doi: 10.1093/cid/ciz405.

[5]. Giri, S., Mohan, V.R., Srinivasan, M., Kumar, N., Kumar, V., Dhanapal, P., Venkatesan, J., Gunasekaran, A., Abraham, D., John, J., and Kang, G., "Case-control study of household and environmental transmission of typhoid fever in India," *J. Infect. Dis.*, vol. 224, suppl. 1, pp. S584–S592, 2021. doi: 10.1093/infdis/jiab378.

[6]. Gurtler, J.B., Doyle, M.P., Erickson, M.C., Jiang, X., Millner, P., and Sharma, M., "Composting to inactivate foodborne pathogens for crop soil application: A review," *J. Food Prot.*, vol. 81, no. 11, pp. 1821–1837, 2018. doi: 10.4315/0362-028X.JFP-18-217.

[7]. Kamweru, G.N., "Assessment of households' knowledge, attitudes and practices on solid waste management in Nakuru Town," unpublished, 2019.

[8]. Kasuku, W., "Typhoid fever, a public health problem in hospitals: Case study at a work station in Kinshasa, DR Congo," *Juniper Online J. Public Health*, vol. 2, no. 3, pp. 3–6, 2017. doi: 10.19080/jojph.2017.02.555586.

[9]. Kim, C., Goucher, G.R., Tadesse, B.T., Lee, W., Abbas, K., and Kim, J.H., "Associations of water, sanitation, and hygiene with typhoid fever in case–control studies: A systematic review and meta-analysis," *BMC Infect. Dis.*, vol. 23, no. 1, pp. 1–17, 2023. doi: 10.1186/s12879-023-08452-0.

[10]. Kim, C.L., Maria, L., Espinoza, C., Vannice, K.S., Tadesse, B.T., Owusu-Dabo, E., Rakotozandrindrainy, R., Jani, I.V., Teferi, M., Soura, A.B., Lunguya, O., Steele, A.D., and Marks, F., "The burden of typhoid fever in sub-Saharan Africa: A perspective," *Res. Rep. Trop. Med.*, vol. 13, no. 1, pp. 1–9, 2022.

[11]. Obsa, O., Tadesse, M., Kim, D.G., Asaye, Z., Yimer, F., Gebrehiwot, M., Brüggemann, N., and Prost, K., "Organic waste generation and its valorization potential through composting in Shashemene, Southern Ethiopia," *Sustainability*, vol. 14, no. 6, pp. 1–19, 2022. doi: 10.3390/su14063660.

[12]. Okesanya, O.J., Eshun, G., Ukoaka, B.M., Manirambona, E., Olabode, O.N., Adesola, R.O., Okon, I.I., Jamil, S., Singh, A., Lucero-Prisno, D.E., Ali, H.M., and Chowdhury, A.B.M.A., "Water, sanitation, and hygiene (WASH) practices in Africa: Exploring the effects on public health and sustainable development plans," *Trop. Med. Health*, vol. 52, no. 1, 2024. doi: 10.1186/s41182-024-00614-3.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25oct1109

[13]. Okin, Y.K., Yabar, H., Kevin, K.L., and Mizunoya, T., "Geospatial analysis of malaria and typhoid prevalence due to waste dumpsite exposure in Kinshasa districts with and without waste services: A case study of Bandalungwa and Bumbu, Democratic Republic of Congo," unpublished, 2024.
[14]. Sciences, I. of E., "WWC standards brief: Baseline equivalence," *Inst. Educ. Sci.*, pp. 2–3, Sept. 2013.
[15]. Sentamu, D.N., Kungu, J., Dione, M., and Thomas, L.F., "Prevention of human exposure to livestock faecal waste in the household: A scoping study of interventions conducted in sub-Saharan Africa," *BMC Public Health*, vol. 23, no. 1, pp. 1–11, 2023. doi: 10.1186/s12889-023-16567-x.
[16]. Ssemugabo, C., Wafula, S.T., Lubega, G.B., Ndejjo, R., Osuret, J., Halage, A.A., and Musoke, D., "Status of household solid waste management and associated factors in a slum community in Kampala, Uganda," *J. Environ. Public Health*, vol. 2020, pp. 1–10, 2020. doi: 10.1155/2020/6807630.
[17]. WHO, "Typhoid vaccines," *Wkly. Epidemiol. Rec.*, vol. 75, no. 32, pp. 257–264, 2018. doi: 10.1016/s0140-6736(67)90344-3.
[18]. WHO, "Sanitation 22," Geneva: World Health Organization, 2024.
[19]. World Bank, "Enumerator training agreement," Washington, DC: World Bank, 2024.
[20]. Yushananta, P., and Putri, M.F.E., "Household and environmental typhoid fever transmission in Bandar Lampung City, Indonesia: A case-control study," *J. Nepal Med. Assoc.*, vol. 62, no. 277, pp. 564–569, 2024. doi: 10.31729/jnma.8744.
[21]. Yushananta, P., and Putri, M.F.E., "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," *IEEE Transl. J. Magn. Japan*, vol. 2, pp. 740–741, Aug. 1987 [Digests 9th Annu. Conf. Magnetics Japan, p. 301, 1982].