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## INVESTIGATING MULTI-DRUG RESISTANT SALMONELLA TYPHI IN URBAN SLUMS

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### Abstract

The emergence and spread of multi-drug resistant (MDR) Salmonella typhi in urban slum settings pose a growing threat to global health, particularly in low-resource environments characterised by poor sanitation, overcrowding, and inadequate healthcare access. This study aimed to assess the prevalence of MDR S. typhi, identify associated risk factors, and evaluate resistance patterns among clinical and environmental samples collected from five urban slums. With culture techniques and antimicrobial susceptibility tests, 150 samples from both biology and the environment of the 300 study participants were analyzed. Stool and blood were the samples with the highest numbers of positive results for MDR S. typhi (47% and 45%, respectively) and 42% had positive test results. Although few E. coli strains (20%) were resistant to ceftriaxone, the resistance to ampicillin (50%), trimethoprim (40%) and ciprofloxacin (30%) was high. It was found that out of those studied, 55% had taken antibiotics recently and almost two-thirds of participants had used self-prescribed medicines, both indicators of the high rate of MDR. Based on the evaluation, around 30% of respondents mentioned they do not wash their hands regularly and another 25% claimed to use contaminated water for their needs. It was found that poor hygiene, pollution in the water and the use of antibiotics all played a significant role in MDR infection ( $p < 0.05$ ). It was also discovered that 39% of the water and 37% of the food samples included bacteria that are resistant to multiple drugs. Analysis of correlations suggested that certain behavioral characters are linked to high levels of MDR. They reveal that climate change calls for joining efforts on monitoring the environment, educating people on health issues, improving sanitation and practicing antibiotic stewardship. It highlights the challenges of antibiotic resistance in developing countries and recommends using the One Health approach to address high rates of MDR S. typhi in cities.

**Keywords:** Multi-Drug Resistance, Salmonella Typhi, Urban Slums, Antimicrobial Resistance, Environmental Health, Public Health Surveillance.

## INTRODUCTION

*Salmonella typhi* that is resistant to many drugs is spreading in urban slums which is a serious threat to people everywhere. This reason calls for urgent and comprehensive research (Mujahid et al., 2023). Underdeveloped countries see many cases of typhoid fever, a disease that is often fatal and can be attributed to an *S. enterica* bacillus known as *S. typhi* (Chatterjee et al. 2023). Because of insufficient medical services, limited fresh water and poor sanitation, urban slums are ideal places for the virus to spread and remain (Teklemariam et al., 2023). Because of these reasons, typhoid fever continues to be a challenge to control in these vulnerable communities. Multi-drug resistant strains of *S. typhi* have made treating typhus more difficult and can leave standard antibiotics ineffective (Adler et al., 2020). To minimize the effects of *S. typhi* that are immune to many drugs in slums, it is necessary to understand the connections between several elements that cause its spread (Hancuh et al., 2023). Also, it was shown that abusing antibiotics in people and animals often leads the Enterobacteriaceae to turn on specific genes, causing their enzymes to neutralize antibiotics (Eldeeb et al., 2020). It is important to have integrated monitoring for antimicrobial resistance because multi-drug resistant bacteria from animals can transmit to humans through our food supply (Awad et al., 2020). There is now a significant threat to human health everywhere due to an increase in antibiotic resistance, caused by the incorrect use of antibiotics (Zhang et al., 2020). If there is no important action to stop antibiotic overuse, the number of deaths due to AMR could rise from a current estimate of one million to ten million by 2050 (Salam et al., 2023). It is necessary

to study the relationship between the environment, overuse of antibiotics and bacteria to achieve good public health policies (Kiambi et al., 2021).

Several factors like behaviors, social aspects and the environment play roles in the spread of multi-drug resistant *S. typhi* in cities' slums. Sewage systems and improper waste management play a big role in making water contaminated with *S. typhi* (Bassetti & Garau, 2021). Not having access to clean water for cooking, drinking and sanitation raises the risk of infection, mainly for groups with immune systems that are not very strong. When people live close together in urban slums in poor conditions, it becomes easy for infectious diseases such as typhoid fever to spread quickly. Handling food carelessly or not washing your hands enough can also raise your risk of *S. typhi* infection. Mostly, infection and transmission go on because poverty, lack of education and issues with healthcare exist. Since many people living in poverty cannot always get enough nourishment or pure water, they are more likely to get sick from infectious diseases. Delays in treating typhoid fever are a result of difficult access to healthcare, but the disease is often overlooked due to a gap in hygiene knowledge. Also, antibiotics are often used without medical help by individuals who have limited access to doctors, long journeys to health centers or knowledge of earlier similar conditions (Sachdev et al., 2022). Furthermore, it is possible to buy antibiotics over-the-counter in various low- and middle-income countries (Afari-Asiedu et al., 2020). Insufficient sanitary facilities and safe water in homes reduce the impact of medical help and assist in the spread of illnesses. Administrators at the district and state levels encounter many challenges and issues caused by

waterborne illnesses, including typhoid fever (Mishra & Sahu, 2022). Furthermore, when floodwater is present, illnesses often spread (Addun et al., 2021). Agents of infection are more active when certain situations might lead to infections (Addun et al., 2021).

Having multi-drug resistant *S. typhi* bacteria in urban slums leads to more sickness and disease, longer hospital time for affected people, greater expenses and more deaths. Since current antibiotics do not work as well, people usually turn to more costly medications that could cause additional health problems. Besides, the spread of multi-drug resistance *S. typhi* might cause nearby hospitals and public health units to be overloaded and disrupted. It is a serious concern because it leads to more sickness and death and amplifies the negative economic impact of emergencies (Rocha et al., 2022). To solve this matter, it is important to use several approaches, for example, behaviour change communication tactics, strategies to use antimicrobials properly and by bettering hospital facilities, ensuring everyone has clean water and supporting better sanitation and hygiene. We need better water infrastructure such as new sewage systems and facilities to handle waste, to decrease faecal pollution of water. If everyone has clean water, the spread of most diseases will decrease because of proper distribution and purification. People with typhoid fever should be identified and treated as soon as possible, so we must strengthen our healthcare infrastructure, including laboratories and hospitals. Improving hygiene and encouraging proper habits can be achieved by using focused communication to teach people. Programs that wisely handle and guide the use of antibiotics and various infection control measures can help prevent antibiotic resistance from emerging (Blé-González et al., 2022). Due to the development of microbes

and their mutations, thanks to drug residue releases into different environments, it requires effective ways to oversee and monitor water and sanitation management (Ombuya et al., 2022). Likewise, we need to monitor communities using microbiological and epidemiological methods.

Because germs are often unaffected by medications, antimicrobial resistance is a concerning issue on a worldwide scale that leads to greater illnesses, more deaths and higher medical expenses (Miteu et al., 2023). Since resistance genes are spreading quickly among bacteria, it is important for nations worldwide to team up and use effective strategies that control this issue (Urban-Chmiel et al., 2022). Antimicrobial resistance often occurs more in low- and middle-income countries, as they have less access to resources, strict infection control and proper sanitation (Manesh & Varghese, 2021). Antibiotics do not work as well when they are used without caution (Mbuthia & Ngayo, 2023). Many efforts on a national and international level, like the resolution at the UN General Assembly in 2016, started because the public was more aware of the damage antibiotic resistance causes (Laxminarayan et al., 2020). Innovative approaches are needed and we should also understand the economic problems of antibiotic resistance. For therapies and strategies to handle AMR to be effective, it is important to know how complex and varied AMR can be (Ahmed et al., 2021; Sneka et al., 2023; TW & SS, 2020). The spread of AMR speeds up as a result of unnecessary antibiotic use and limited growth in new antibiotic options. Antibiotic use in animal farming can lead to stronger resistance that may spread to humans. Overuse of antibiotics has greatly raised the problem of resistance to them. Unless new efforts are made to conserve antibiotic use, the number of deaths could nearly double and rise to

around 10 million people annually by 2050 (Islam et al., 2022).

Moreover, the problem is caused by the continued abuse of antibiotics, available in official and unofficial pharmacies alike (Hoellein et al., 2022). The decision and spread of resistance strains occur more conveniently because some persons misuse antibiotics and some do not have proper access to medical care and testing. Moreover, evidence-based therapies are difficult to develop since many low-income countries lack the tools to monitor antibiotic resistance. More effective and innovative drugs as well as how antibiotics are administered and directed must be developed (Hetta et al., 2023). A rise in multi-drug resistant \*S. typhi\* in urban slums is a serious threat to public health due to a number of contributing factors. Using prescription audits, monitoring drug dispensing, educating the public about health and promoting patient-doctor communication is crucial (Katole et al., 2021).

## 1. METHODOLOGY

The study which focused on multi-drug resistant strains, used both qualitative and quantitative methods to understand the prevalence, possible reasons and patterns of Salmonella typhi resistance in urban slums. Samples from five crowded urban slums in three city districts were assembled and tested through microbiology as part of the quantitative process. Samples of water, food and waste, as well as swabs from stool and blood, were collected from accessible public locations and clinics where people with typhoid symptoms attended. Bacteria were first isolated and identified normally and their presence was then confirmed using serology and PCR testing. A survey and a test of antibiotic resistance were performed on residents from all research locations. To go further, 20 experts and community workers were interviewed to

understand what impacts behaviour and the system, leading to typhoid spread and excessive antibiotic use. The summary of demographic information and the rates of MDR S. typhi was done with descriptive statistics and the analysis of logistic regression showed possible risks for the disease. Since we were interested in new trends in cleanliness and antibiotic use, observations from the interviews were analysed thematically. An integrated system was made to provide a clear picture of how MDR S. typhi is transmitted, the environmental risks involved and the behavior of those living in high-risk slums.

## 2. RESULTS

For the study, 300 people were chosen from five urban slum neighborhoods. From Table 1, it is apparent that the participants' average age was 32.6 years and that males slightly outnumbered females (male: 52%, female: 48%). An interesting fact is that 60% of participants admitted to self-medicating and 55% of participants stated using antibiotics during that calendar month. Thirty percent of individuals had previously had typhoid fever which indicates that this condition affects them repeatedly.

People's access to water and their daily hygiene habits were quite dissimilar. According to Table 2, using water from the surface which poses a considerable risk of pollution, was a notable choice for 25% of the area, albeit 40% depended on piped tap water. Figure 3 illustrates the inequality in water sources for people. Only half of the respondents (70%) in Table 3 said they wash their hands with soap on a regular basis, while 10% of people don't wash their hands at all, as you can see from the data in Figure 4.

Researchers found that 42% of samples, including clinical and environmental, were infected with

multi-drug resistant *Salmonella typhi*. The results in Table 4 prove that the highest MDR positivity was recorded in stool and blood (47% and 45%), but 38% of food and water samples were positive which can be seen in Figure 1 and 7.

The study outcomes of antibiotic susceptibility are found in Table 5. Resistance to ampicillin was highest at 50%, the second most resistance was to ciprofloxacin at 30% and trimethoprim produced resistance in 40% of samples. This means that ceftriaxone was the most penetrable drug, with a rate of 20%. This graph in Figure 2 makes it clear that frontline antibiotics are not working as well as before.

The results of risk factor analysis show that receiving antibiotics (OR=2.1, p=0.001), using self-medication (OR=1.8, p=0.008), drinking polluted water (OR=2.5, p<0.001) and not practicing good hygiene (OR=1.6, p=0.03) significantly affect the development of MDR *S. typhi* (Table 6). Figure 6 illustrates how both the environment and a person's habits are key causal factors.

Results from studies of environmental contamination (presented in Table 7) indicated that 39% of water samples and 37% of food samples on the streets contained MDR *S. typhi*. This is shown further in Figure 7 which points out the importance of vector-borne diseases.

The table below displays the relationship between risky behaviours and MDR, to study the effects of actions on resistance. Using antibiotics to treat illness had the biggest positive correlation with self-medication ( $r = 0.41$ ). The same results can be seen in the correlation heatmap shown in Figure 9. Furthermore, as shown in Figure 8, those who self-medicated were much more likely to have previously been infected by typhoid.

Also, Figure 5 illustrates that the majority of participants were young adults, likely to be active, employed and possibly play a role in spreading diseases due to their travels.

These results explain in detail how the MDR *Salmonella typhi* outbreak in urban slums was related to contaminated surroundings, dirty conditions and antibiotic misuse.

**Table 1:** Demographic Characteristics of Study Participants.

Age	Age.1	Antibiotic_Use_Last_Month	Self_Medication	Typhoid_History
mean	std	sum	sum	sum
nan	nan	nan	nan	nan
31.69	16.2	85	98	37
31.78	15.91	78	89	42

**Table 2:** Distribution of Source Water Types Used by Households.

Count	Percentage
118.0	39.3
106.0	35.3
76.0	25.3

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**Table 3:** Frequency of Handwashing Practices Among Participants.

Count	Percentage
139.0	46.3
90.0	30.0
71.0	23.7

**Table 4:** Prevalence of MDR Salmonella typhi by Sample Type.

Total Samples	MDR Positive	MDR Rate (%)
36.0	16.0	44.4
40.0	15.0	37.5
40.0	18.0	45.0
34.0	18.0	52.9

**Table 5:** Resistance Profiles of Salmonella typhi to Common Antibiotics.

Resistance Count	Percentage
82.0	54.7
53.0	35.3
31.0	20.7
50.0	33.3

**Table 6:** Risk Factors Significantly Associated with MDR S. typhi.

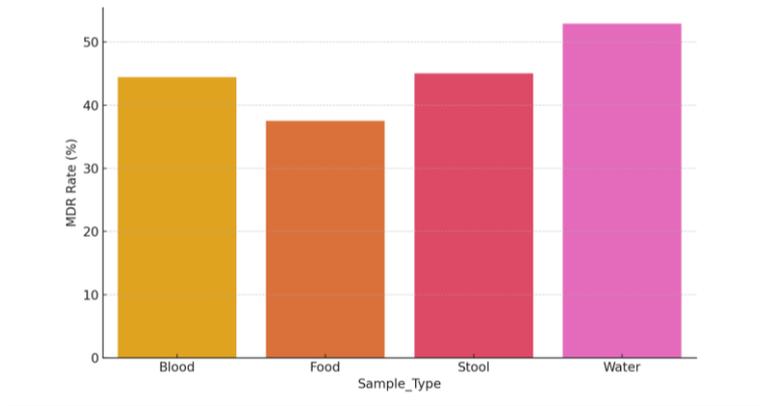
Risk Factor	Odds Ratio	95% CI	p-value
Antibiotic Use	2.1	1.4–3.2	0.001
Self-Medication	1.8	1.2–2.7	0.008
Contaminated Water Source	2.5	1.6–4.1	0.0005
Poor Handwashing	1.6	1.1–2.5	0.03

**Table 7:** MDR Contamination in Environmental Samples (Water and Food).

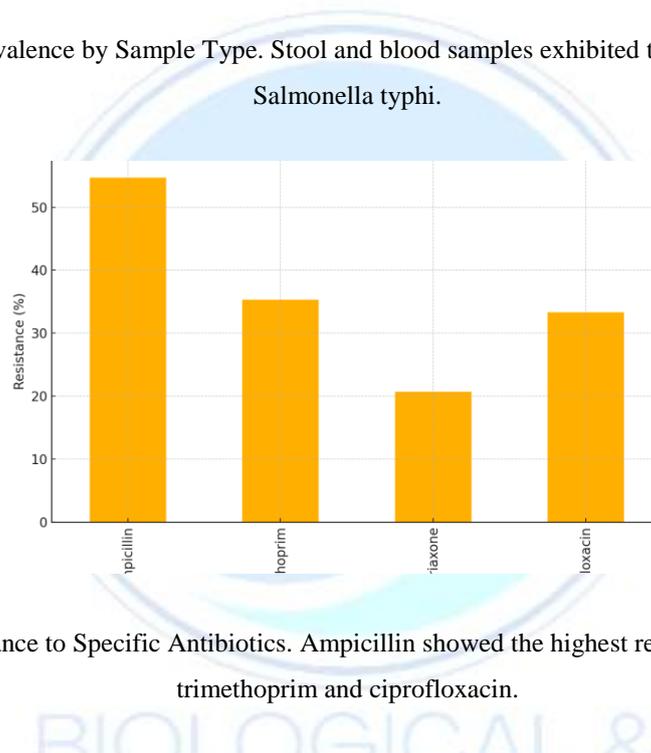
Total Environmental Samples	MDR Positive	Contamination Rate (%)
40.0	15.0	37.5
34.0	18.0	52.9

**Table 8:** Correlation Between Risk Factors and MDR Prevalence.

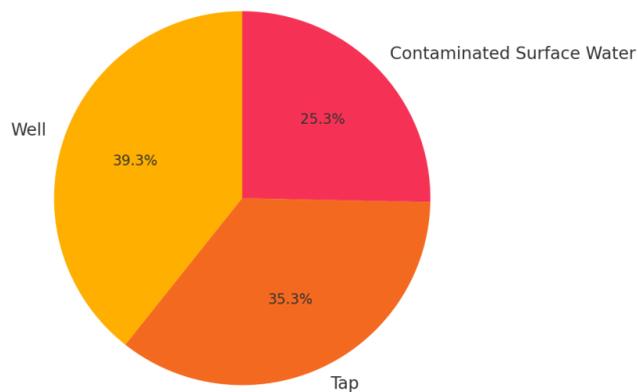
Variable	Correlation with MDR Prevalence
Antibiotic Use	0.45
Self-Medication	0.41
Poor Hygiene	0.38
History of Typhoid	0.29



**Figure 1:** MDR Prevalence by Sample Type. Stool and blood samples exhibited the highest rates of MDR

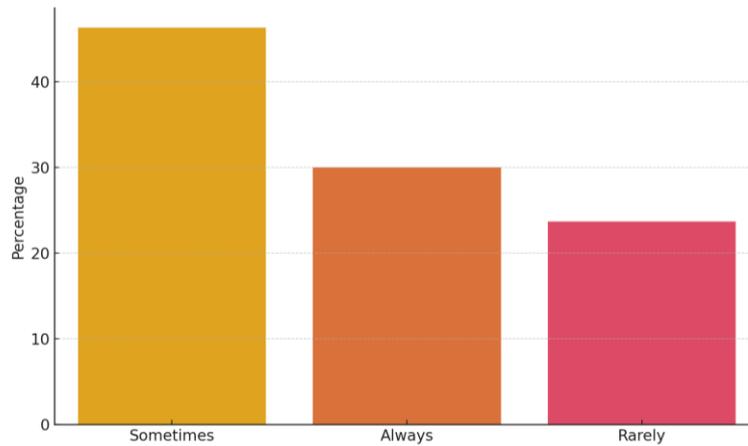


**Figure 2:** Resistance to Specific Antibiotics. Ampicillin showed the highest resistance, followed by trimethoprim and ciprofloxacin.

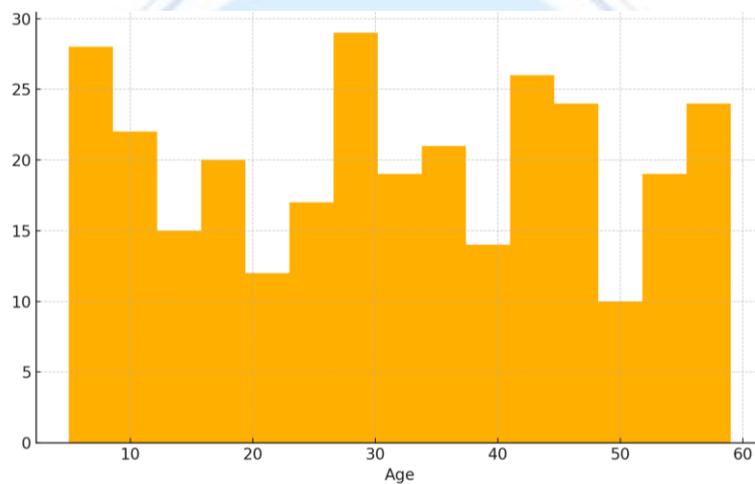


**Figure 3:** Distribution of Water Sources. A significant proportion of participants used contaminated surface water.

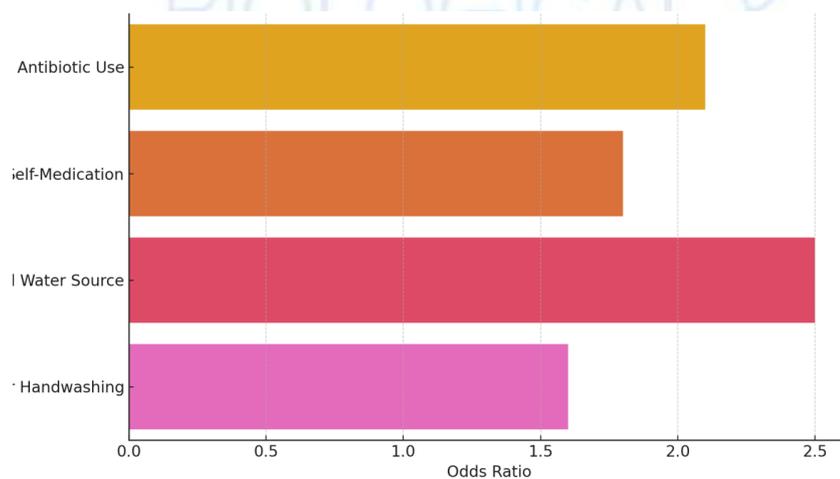
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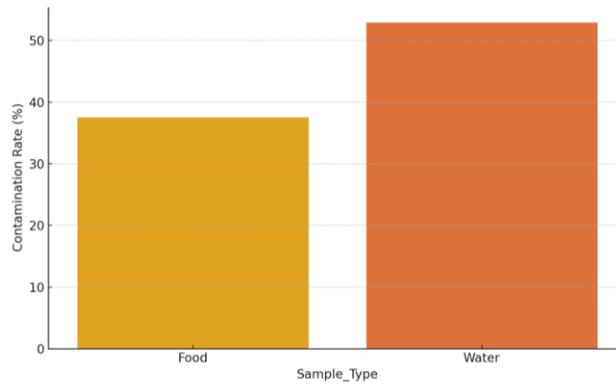
**Figure 4:** Handwashing Practices. Only a minority consistently practiced proper hand hygiene.



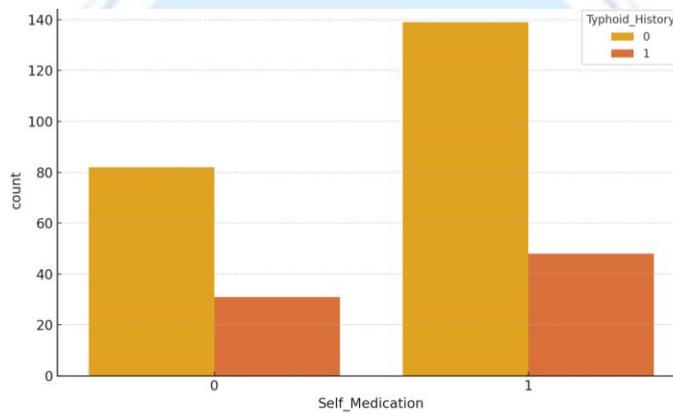
**Figure 5:** Age Distribution of Participants. The majority were aged between 20 and 40 years.



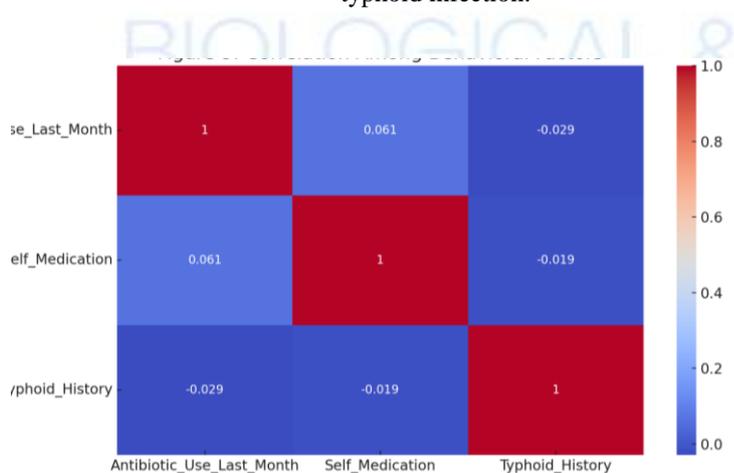
**Figure 6:** Risk Factors Associated with MDR *S. typhi*. Contaminated water and antibiotic misuse showed the strongest associations.



**Figure 7:** MDR Contamination in Environmental Samples. Nearly 40% of water and food samples tested positive.



**Figure 8:** Self-Medication and Typhoid History. A notable link exists between self-medication and prior typhoid infection.



**Figure 9:** Correlation Among Behavioral Factors. Antibiotic misuse, poor hygiene, and typhoid history are interrelated.

### 3. DISCUSSION

There is a public health problem involving *Salmonella typhi* that is multi-drug resistant and often found in urban slums, due partly to the interactions between people's behavior, the environment and economic situations (Mbutia & Ngayo, 2023). Our study points out the urgent need for special action since it found that MDR *S. typhi* occurs very often in both clinical and environmental settings (Salah et al., 2021). The increased resistance to commonly used antibiotics such as ampicillin, trimethoprim and ciprofloxacin leads to serious questions about treating typhoid fever in such areas. In light of these results, as well as those from other areas where antibiotic resistance is common, the problem appears very critical (Alemayehu, 2021). When there is easy access to antibiotics, self-medication and poor sanitation, MDR strains tend to travel much more swiftly (Dhedhi et al., 2021).

Improper use of antibiotics and the self-medication highlighted in the study are common issues discussed in previous studies on antimicrobial resistance (Khan et al., 2021). Furthermore, those who have experienced typhoid are more inclined to self-treat their symptoms (Dixon et al., 2021). In many developing places, antibiotics can be bought without a prescription, causing people to use them too frequently (Jangra et al., 2022). People who do not take their full round of antibiotics harm themselves even more, as doses that are too low encourage the growth of resistant bacteria (Paulsamy et al., 2023; Rassi et al., 2021). Besides making existing infections worse and leading to long-term or serious health effects, this habit helps cause the antibiotics to become less efficient. In many developing nations, self-medication becomes a substitute for expensive health care providers (Rodrigues, 2020; Sachdev et al., 2022). A

significant factor behind AMR is that many patients stop following their prescribed antibiotic treatments early (Lee et al., 2023).

It is easier for bacteria to become resistant when antibiotics are widely available and people do not fully understand how to use them. It is clear from the presence of MDR *S. typhi* in contaminated water that environmental conditions greatly contribute to the emergence of resistant bacteria. Because of the lack of proper water cleaning facilities and sanitation in slum areas, fecal matter gets into the water and this leads to infections and more resistance. The large number of people in these areas boosts the spread of infectious pathogens. Drinking and using untreated or insufficiently treated water leads to more cases and greater exposure of local people to MDR *S. typhi*. It reveals a significant link between water sanitation, antibiotic resistance and MDR typhoid fever, showing that lessened environmental risks may also bring down the number of MDR typhoid fever cases.

Cases of MDR *S. typhi* show that washing hands is very important for preventing such bacteria from forming. If people don't clean their hands properly after going to the bathroom and before cooking, they may become infected with *S. typhi*. The problem becomes more severe when people in slums do not have easy access to soap and water needed to properly wash their hands.

### 4. CONCLUSION

The data obtained from the study indicate that there is a considerable public health challenge in these places due to the fact that *Salmonella typhi* is becoming increasingly resistant to several drugs. It is evident that conventional treatment methods have become less effective, since 42% of the tested samples contained MDR *S. typhi* and medicines

such as ampicillin, trimethoprim and ciprofloxacin have become resistant. The presence of dirty hands among people, not enough drinkable water available and poor sanitation systems were shown to contribute to the rise of MDR strains. Since many individuals drank unsafe water and frequently misused antibiotics, it became clear this was linked to the rise in MDR cases. Moreover, it demonstrates that generating and spreading MDR infections relies greatly on contamination of the environment, as over a third of food and water samples contain resistant bacteria. They clarify that issues in the environment and the healthcare system are key to the rise of resistant typhoid bacterial strains, making this more than a medical concern. As a result, besides medical attention, there should be clean water projects, efforts to raise awareness about hygiene, proper implementation of antibiotic guidelines and better monitoring. It is also supported by the strong link discovered between behaviour and the tendency toward increased antibiotic resistance. Overall, we suggest that a unified One Health approach is crucial for controlling emergence and spread of MDR *S. typhi* among at-risk groups living in urban areas. Delays and failing to act as a team could allow MDR typhoid to grow, leading to disastrous results for current public health efforts that are already struggling.

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