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Typhoid Outbreak in Mbare, Suburb of Harare City, 2017

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Abstract

Introduction: Typhoid fever is a life-threatening epidemic prone disease caused by a gram negative bacterium, *Salmonella Typhi (S. Typhi).* Typhoid fever is a notifiable disease in Zimbabwe under the public health act. Typhoid fever continues to pose an important public health problem especially in urban setting. Typhoid diseases occurrence in Zimbabwe is reported to be endemic as it is now known to occur every year, and manly due to poor sanitation and erratic water supply. Humans are the only natural host and reservoir of the bacteria and spread is from person to person through the fecal-oral route, by ingestion of food or water contaminated with faecal matter. The incubation period is usually 8- 14days but can range from 3 days to 2 months. City Health Department reported 245 cases of suspected typhoid fever cases from October 2016 to February 2017. An investigation was initiated to identify possible source of transmission so as to institute control measures.

Methods: An unmatched 1:1 case-control study was conducted. An interviewer based questionnaire was administered to study participants so as to identify risk factors for contracting typhoid in Mbare. A case was described as a resident of Mbare who presented with a Fever of 38^0C and other signs and symptoms of typhoid between October and January 2017. Water samples were collected from boreholes and municipal water for microbiological analysis. Data was analyzed using Epi Info statistical package version 7.2.0.1.

Results: 72 cases and 72 controls were enrolled in the study. Drinking water from a borehole [OR= 5.9 (2.12-18.46), p=0.02], attending a gathering [OR= 3.9, 95% CI= (1.33-7.56) p=0.032], boiling drinking water [OR= 0.24, 95% CI= (0.09-0.62), p=<0.001], and burst sewer pipe or refuse within 500m of household [OR= 9.83 95% CI= (3.81-24.41) p=0.025], were factors associated with contracting typhoid. Independent risk factors for contracting typhoid were drinking water from a borehole [AOR= 5.9, 95%CI= (2.12-18.46) p=0.03], and burst sewer pipe at home [AOR=9.23; 95% CI= (3.81-2.26) p=0.04)]. Faecal coli forms and E. coli and salmonella were isolated from 22/37 boreholes samples. 11/12 school boreholes were contaminated with E. coli and salmonella. 2/2 municipal water had 0.08-0.2mg/liter of residual chlorine, instead of the 0.2mg/liter recommended. Stool and blood specimens were cultured and serotyped for Salmonella typhi and 30 cases were confirmed positive. Ciprofloxacin, Erythromycin and Rocephin were used for case management.

Conclusion: Contaminated water from borehole was the probable source of the outbreak as most of the boreholes were wrongly cited and shallow. Boiling water and the use of narrow mouthed water containers for water storage was a protective factor. Harare City Engineer must invest in repairing water and sewage reticulation systems in Mbare and other high density areas. The surveillance system for typhoid failed to detect some of suspected typhoid cases as the cases were misdiagnosed. This was a point source outbreak and is supported by the incubation period which was suggestive of common contamination from contaminated boreholes due to sewer sippage into the poorly constructed boreholes and poor sanitation.

Keywords: Typhoid, outbreak investigation, contaminated boreholes, Harare City Health

Introduction

Typhoid fever is a notifiable disease in Zimbabwe under the public health act. Typhoid fever continues to pose an important public health problem especially in urban setting [1]. Typhoid diseases occurrence in Zimbabwe is reported to be endemic as it is now known to occur every year, and manly due to poor sanitation and erratic water supply. The last recent outbreak in Harare occurred in the first quarter of 2016, and was declared over in July 2016.

Typhoid fever is a life-threatening epidemic prone disease caused by a gram negative bacterium, *Salmonella Typhi (S. Typhi)*. Humans are the only natural host and reservoir of the bacteria. Persons with typhoid fever carry the bacteria in their bloodstream and intestinal tract [1, 2]. Typhoid fever is spread from person to person through the fecal-oral route, by ingestion of food or water contaminated with faecal matter [2]. *S. Typhi* may also be found in vomitus and urine. Polluted water is the most common source of transmission. The incubation period is usually 8- 14days but can range from 3 days to 2 months.

Objective

To investigate the outbreak of Typhoid Fever among residents of Mbare, from October 2016-February 2017

Study Design

An Unmatched 1:1 case control study was conducted.

Study Setting

The study was conducted in Mbare, a suburb in the south district of Harare City in Zimbabwe.

Study Population

The study population included all eligible participants residing in Mbare at the time of the study. The key informants were the DHE members and the sister in charge who answered questions to evaluate the emergency response measures implemented by the department.

Clinical Records

Clinical records of cases who suffered from typhoid from 22nd of October 2016 to 28 February 2017 were reviewed to evaluate case management.

Case Definition

A case was defined as any patient who presented at Mbare poly clinic from the 22nd of October 2016 to 28 February 2017 and reported having symptoms as defined in the case definition of typhoid.

A **case** therefore presented with any or more of the following symptoms: fever of at least 38 degrees Celsius and above, for more than 3 days, General body malaise, Headache, Vomiting, and Diarrhea / constipation.

A **control** was defined as a person staying in a neighboring household who did not have symptoms compatible with those as shown by the cases during the same period from 22nd October 2016 to 28 February 2017.

Sample size calculation

One control was selected for each case from the neighboring household or street were the case was coming from.

Cases were selected using an intensified case finding strategy and also through hospital line list**.** Using stat Cal the Epi Info version 7.2.0.1 and factoring in handwashing as a risk factor (OR=2.83) [14] and making the following assumptions**:**

- 95% level of confidence
- 80% power
- Exposure of controls to typhoid contact 6%
- case control ratio of 1:1

The sample size is 65 cases and 65 controls. Factoring in a refusal rate of 10% the final minimum sample size is 73 cases and 73 controls.

Sampling Procedures

For cases, a person who resides in Mbare who was treated for typhoid from 22nd October 2016 to 28 February 2017. A line list with 234 participants was obtained at Mbare poly clinic complimenting identification of participants who received typhoid treatment during the same period. Systematic random sampling for the cases was be done by selecting cases in the registers. A random number was picked from 1-5, and sampling interval of 3 [234/72 =3. If the client was not available a replacement was done with the next number 4] to choose cases.
Controls were selected from the same area a case was coming from. They were individuals who did not present with symptoms of typhoid during the same period.

Data Collection

Interviewer administered structured questionnaires were used for both cases and controls to collect data on the risk factors and knowledge and practices related to typhoid. A review of notes of all the cases included in the study was carried out to evaluate case management. A checklist was used to assess the sanitation facilities of the households. An adapted WHO integrated Disease surveillance and Response structured questionnaire was used to assess the outbreak response from key informants at the Poly clinic.

Data Analysis

Data was entered into and cleaned using epi info statistical software version 7.2.0.1 and frequencies, proportions and median of variables, tables, measures of association, that is odds ratios, tests for statistical significance, and stratified analysis to assess for possible confounding and effect modification were done. Logistic regression was done to establish the independent risk factors for contracting typhoid at 5% level of significances and 95% confidence.

Qualitative data obtained from key informants and was analyzed using the NVIVO computer package. This programme systematized and facilitated all the steps in qualitative data analysis. It was also possible to manipulate pre- categorized responses to summarize open ended questions.

Intended use of results

Data from this study was used to design awareness programs to be implemented by the City Health Department not only for Mbare but for the entire City of Harare.

Data was used to lobby the City health authorities for improvement of water and sanitation hygiene promotion. The data also informed the health department on how well it is prepared to respond to emergencies such as outbreak of diseases. Data was also used to inform the city health department of their performance on case management and help come up with methods of either maintaining or improving patient case management.

Data Dissemination Plan

Results of this study were disseminated to the City Health Department first through the Director of health services and then to the department through a written report. Mbare polyclinic was also informed of the results of this study in their regular monthly meetings. Presentation to stakeholders was also done.

Publication of the results was done in both local and international scientific journal and presentations.

Results

Description of outbreak by person

A total of 144 participants, 72 cases and 72 controls were interviewed for this study. The median age of the participants was 30 years. More female participants were interviewed (53.47%) compared to males (46.53%). There was no significant difference in the demographic characteristics of the cases and controls. No minors were interviewed among the controls but for those cases who were minors, their parents or guardians were interviewed.

Thirty cases were found to be positive for *Salmonella typhi* in stool, and blood. Two deaths were reported. For the under-fives, males were more affected (34%) than females (28%) while for the rest of the age groups females were more affected. Of all the age groups, the 25 to 44 age group was most affected with 34% male and 32% female cases.

Table 1: Demographic characteristics of the cases and controls Mbare Suburb, January 2017

Attribute		**Cases [N=72] n (%)**	**Controls [N=72] n (%)**
Sex	Male	34(23.61)	34(23.61)
	Female	38(26.39)	38(26.39)
Occupation	Formally Employed	13(18.06)	13(18.06)
	Informally Employed	42(48.28)	45(51.72)
	Unemployed	11(15,28)	9(12.50)
	Student	6(8.33)	5(6.94)
Education	Never been to school	2(2.78)	4(5.56)
	Primary	33(45.83)	21(29.17)
	Secondary	31(43.06)	39(54.17)
	Tertiary	6(8.33)	8(11.11)
Average income	>$480	5(6.94)	5(6.94)
	$100-480	49(48.04)	53(51.96)
	< $100	18(25.00)	14(19.44)

The majority of the participants. 87(60.42%) were informally employed, whilst 20(13.89%) and 27(13.89 %) were formally employed.

The level of education was classified as; those who never went to school; primary; secondary and tertiary. The majority among the participants had secondary education 70(48.61%).

It was found that 26 households had 6 people living in one house followed and another 25 households had 5 people living in one house. The study also revealed extreme cases in which up to 12 people were living in one house.

In terms of average income 70.83% of the participants had an income of $100-480 whilst 22.22% were living with less than a $100 per month.

Knowledge of Typhoid

Table 4.5: Knowledge of typhoid for the cases and controls Mbare Suburb, Oct 2016-Feb17

Characteristics	**Cases N= 72 n (%)**	**Controls N= 72 n (%)**	**P-value**
Heard about typhoid			
Yes	68(94.4)	70 (97.2)	0.0419
No	4 (5.5)	2 (2.8)	
Where heard about typhoid			
Clinic	34 (47.2)	22 (30.6)	
Outreach visits by health staff	15 (20.8)	18 (25)	0.031
Media	20(27.7)	28(38.9)	
Missing data N/A	3 (4.2)	4 (5.6)	
Received typhoid education			
Yes	40 (55.5)	57 (65.3)	0.031
No	32 (44.4)	24 (34.7)	
Where educated about typhoid	**N=40**	**N=57**	
Clinic	18 (45)	16 (28)	
Outreach visits by health staff	5(12.5)	20 (35.1)	0.050
Media	3(7.5)	12 (21)	
Missing data N/A	14(35)	9(15.8)	
Typhoid symptoms			
Yes	69 (95.8)	66(91.7)	0.017
No	3 (4.2)	6 (8.3)	

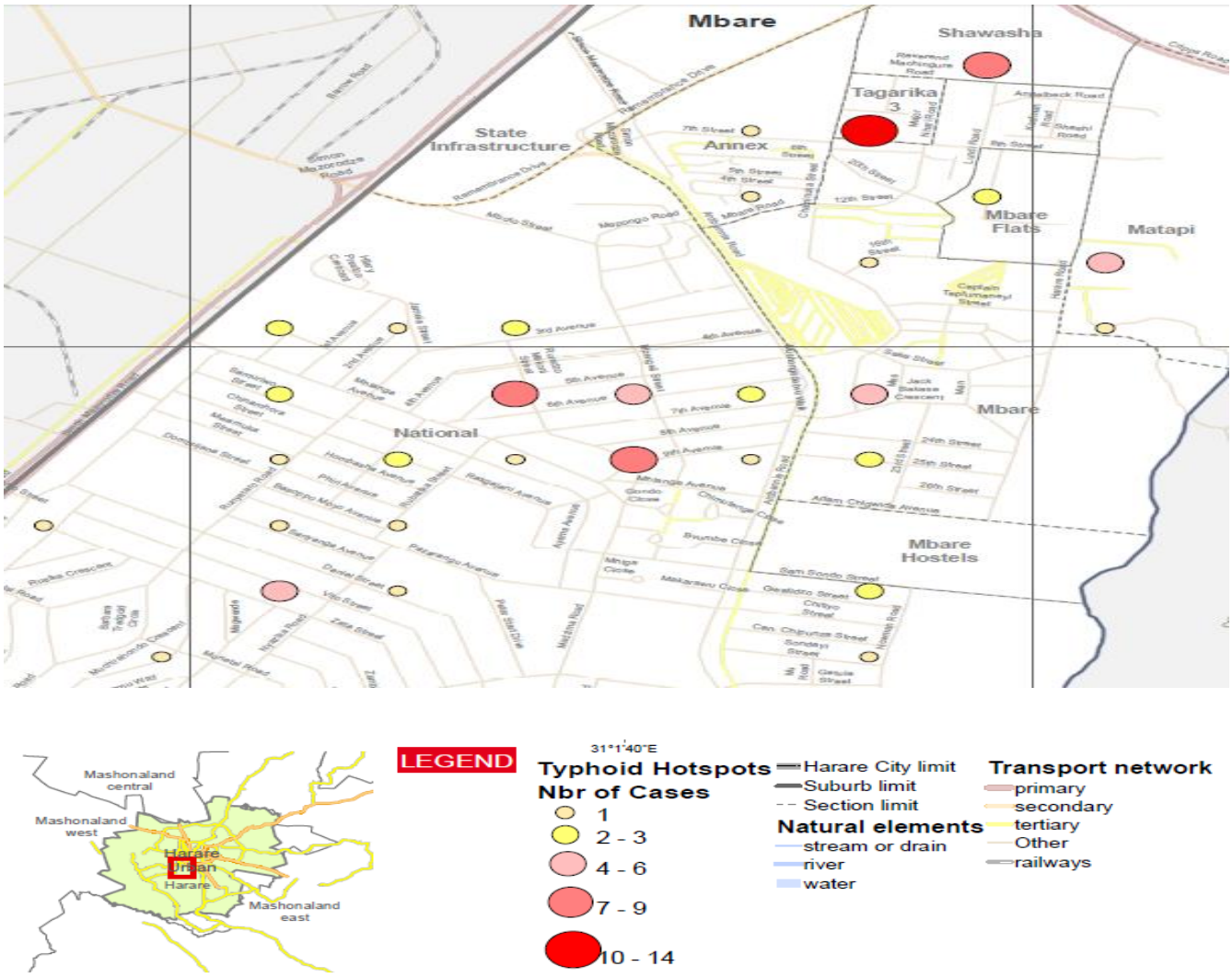
Knowledge on what is typhoid was generally good among both cases and controls. Cases had more knowledge of the symptoms of typhoid compared to controls. More cases (55.5%) than controls (37.5%) knew that fever is a symptom of typhoid. There was no significant difference however in knowledge of the other symptoms between cases and controls for the majority of areas looked as shown in table 4.5 above. However, a significantly higher number of cases 47.8% vs 30.6% controls indicated that they heard about typhoid from the clinic. Further, a

significantly higher number of controls 9% vs 1% cases indicated that they knew of typhoid symptoms.

The relationship between having a typhoid contact at home and contracting typhoid was not statistically significant in the risk of contracting typhoid in this study. Eating cooked food from a street vendor was also statistically insignificant as a risk of contracting typhoid.

Distribution of cases by place

Figure 1: Spot Map of Typhoid Cases Mbare Suburb, Harare 2016-17



The distribution of cases by place is as shown in Figure 1

The initial outlier cases came from Ruredzo Makoni road. The cases then spread to 5th -9th street near Ruredzo makoni road in Mbare National, which were initially hot spot areas and then spread to the rest of Mbare.

Risk factors for Typhoid in Mbare

The risk factors for contracting typhoid in Mbare were analyzed using a 2 by 2 table and are shown in **Table 2** below.

Table 2: Risk factors associated with typhoid outbreak in Mbare Suburb, Harare

Exposure		Cases n=72 (%)	Controls n=72 (%)	OR	95% CI	p value
Eat cooked food from a street vendor	Yes No	67 (52.34) 5 (31.25)	61 (47.6) 11 (68.75)	2.4	0.79-7.35	0.06
Had any burst sewage/ waste in your area	Yes No	71 (98.61) 1 (1.39)	51 (70.83) 21 (29.17)	9.23*	3.81-24.41	0.025
Had received education on typhoid	Yes No	35(42.68) 37(51.39)	47 (57.32) 24 (34.72)	0.50*	0.26-0.98	0.031
Use water from a borehole for domestic use	Yes No	69(95.83) 3(4.17)	68(94.44) 4(5.56)	1.35	0.29-6.27	0.28
Had a typhoid contact at work/home	Yes No	23(31.89) 49 (45.79)	14 (19.44) 58 (54.21)	1.94	0.90-4.18	0.06
Experience any water cuts	Yes No	71 (58.20) 1 (1.39)	51 (41.80) 21 (29.17)	9.23*	3.81-24.42	0.08
Eating at any public gathering	Yes No	63 (57.80) 9 (12.50)	46 (42.20) 26 (36.3)	3.9*	1.33-7.56	0.032
Store water in wide mouthed container	Yes No	19 (37.25) 32 (44.44)	26 (45.71) 40 (55.56)	1.98	1.66-3.34	0.062
Boiling/ treat drinking water	Yes No	7 (9.72) 65 (56.52)	22 (30.56) 50(43.48)	0.24*	0.09-0.62	0.017
Hand washing facility after toilet use	Yes No	13(18.06) 59(55.14)	24(33.33) 48(44.86)	0.44*	0.20-0.96	0.023
Perceive yourself at risk of typhoid	Yes No	45 (62.50) 27 (32.53)	16 (22.22) 56 (67.47)	5.8*	2.80-12.13	<0.001
Storing water in a narrow mouthed container with lid	Yes No	14(19.4) 58 (80.55)	62(86.1) 10 (13.88)	0.35	0.58-0.89	. 0.05

* **Statistically significant factors**

Drinking boiled or treated water [OR= 0.24, 95% CI= (0.09-0.62), p=<0.017], having burst sewage in an area [OR= 9.83 95% CI= (3.81-24.41) p=0.025], Eating at a public gathering [OR= 3.9, 95% CI= (1.33-7.56) p=0.032] were significant risk factors for contracting typhoid in Mbare. Having a hand washing facility after using the toilet was a significant protective

factor, [OR= 0.44, 95% CI= (0.21-0.91) p=0.023]. Receiving education on typhoid was also a protective factor [OR=0.50, 95% CI (0.26-0.98) p=0.031].

Stratified Analysis

The effect of eating at a gathering was stratified by gender as shown in table 3 below.

Table 1: Effect of eating at a gathering stratified by gender, Mbare suburb, Harare

Exposure		Cases	Controls	OR	95% CI	p-value
male: Eating at a gathering	Yes No	29(58.00) 5(14.71)	21 (42.00) 13 (38.24)	3.59	1.11-11.62	0.01
Female: Eating at a gathering	Yes No	34 (57.63) 4 (10.53)	25 (42.37) 13 (34.21)	4.42	1.29-15.18	0.02
Crude Eating at a gathering	Yes No	63 (87.5) 9 (12.5)	46 (63.89) 26 (36.11)	3.92	1.69-9.24	0.001
Adjusted OR (MH) 3.97 (1.69-9.29) χ^2 = 10.78; p=0.001						

The effect of eating at a gathering as a factor associated with contracting typhoid was stratified by gender. Male cases who ate at a gathering were 3.59 times more likely to contract typhoid compared to those males who did not eat at the gathering [(stratum specific OR= 3.59, 95% CI= 1.11-11.62, p= 0.01)]. Female cases who ate at a gathering were 4.42 times more likely to contract Typhoid compared to the females who did not eat at the gathering [(stratum specific OR= 4.42, 95% CI= 1.69-9.24) p=0.02].

Independent Factors Associated with Typhoid

Logistic regression was done to determine independent factors associated with developing typhoid in Mbare suburb. Table 4 shows the independent factors which were found to be associated with contracting typhoid in Mbare.

Table 4: Multivariate analysis of Independent factors associated with contracting typhoid in Mbare Suburb, Harare, 2017

Factor	Cases N=72 n (%)	Controls N=72 n (%)	AOR (95%CI)	p-value
Using water from borehole	68(94.4)	55 (68.47)	5.9 (2.12-18.46)	0.03
Burst sewer pipe or refuse within 500m of home	72 (100)	72(100)	9.23 (3.81-24.42)	0.04

Store water in wide mouthed container	58 (42.1)	36 (24.21)	3.68 (1.54-8.2)	0.05
Not treating/boiling drinking water	61(84.7)	18(13.7)	5.8 (1.90-17.78)	0.03
Storing water in a narrow mouthed container with lid	24(33.3)	62(86.1)	0.45 (0.32-0.85)	0.002

The independent risk factors for contracting typhoid were**:** drinking water from borehole [AOR= 5.9, 95%CI= (2.12-18.46) p=0.03]; storing water in wide mouthed container [AOR= 3.68, 95%CI= (1.54-8.25) p=0.05]; burst sewer pipe or refuse within 500m of household [AOR=9.23; 95% CI= (3.81-2.26) p=0.04]; Storing water in narrow mouthed containers with lid [AOR = 0.45, 95%CI= (0.32-0.85) p=0.002]; not treating/boiling drinking water [AOR= 5.8, 95%CI= (1.90-17.78), p=0.03] and boiling drinking water [AOR = 0.26, 95%CI= (0.06-0.94), p=0.001] was protective

Environmental Assessment

Water supply: Most residents were using borehole water for drinking, and tap water if available for other purposes. City council water supply was erratic and was reported to be dirty and smelly. There were no hand washing facilities after using the toilet.

Water treatment: Residents were not treating borehole water, they perceive it to be clean and safe from previous health education done in the area in 2013.

Sewage blockages: Most residents were complaining of sewer blockages and repairs were not timeously done.

Refuse collection: Refuse dumps were everywhere, including at borehole sites and the entrance of the Poly clinic were the treatment centre was sited. It was noticed that refuse was not collected timeously.

Boreholes: Most boreholes were shallow and were about 25 metres deep, instead of the recommended 50 metres and above. Casings were shaking and had perforations. There was poor workmanship on most boreholes. Some residents in Mbare national were buying water at $0.20 per bucket at a private borehole since they had no public borehole near them in that area. 6/30 boreholes were reported to be non-functional.

Residents were very emotional as they were not happy with the WASH situation in Mbare. The flats, where most participants came from; Nenyere, Shawasha, Matapi and Mbare hostels had dilapidated sewer system, infrastructure and overcrowded. There were sewage dropping from

one floor to another, council workers were no longer cleaning their communal kitchens, bathrooms and toilets as a result maggots were found everywhere.

Water sampling

Table 5: Results of micro biological analysis of borehole water from Mbare boreholes and municipal water

Sample	Total coliform count (cfu/ml)	Total E. Coli count (cfu/ml)	Salmonella spp	Shigella spp
WHO Guidelines 2008	0/100ml	0/100ml	0/100ml	0/100ml
F65/17	NG	NG	NG	NG
F66/17	13	Positive	NG	NG
F24/17	24	NG	NG	NG
F02/17	TNTC	02	Positive	NG
F37/17	TNTC	NG	Positive	NG
F38/17	29	NG	Positive	NG
F39/17	TNTC	NG	Positive	NG
F29/17	TNTC	05	Positive	NG
F57/17	TNTC	NG	Positive	NG
F58/17	TNTC	NG	Positive	NG
F59/17	TNTC	05	Positive	NG
F03/17	TNTC	02	Positive	NG
F08/17	15	NG	Positive	NG
F20/17	10	NG	Positive	NG
F12/17	08	05	Positive	NG
F66/17	13	Positive	Positive	NG
F37/17	TNTC	NG	Positive	NG
F33/17	29	NG	Positive	NG
F30/17	TNTC	NG	Positive	NG
F32/17	TNTC	05	Positive	Positive
F36/17	TNTC	NG	Positive	NG
F28/17	TNTC	NG	Positive	Positive

KEY

TNTC **Too numerous to count**

NG **No growth**

According to the microbiological analysis done on samples of water collected from boreholes and municipal taps Water sampling for 37 boreholes was done and results had too many faecal coliforms to count, 22/37 boreholes sampled were positive for Salmonella and E. coli. Two (2) municipal tap water was also sampled and one was positive for faecal coliforms and salmonella and had residual chlorine ranging from 0.08- 0.1 mg/liter instead of the WHO recommendation of 0.2 mg/liter. Samples from school boreholes were also sampled and 11/12 boreholes were contaminated with salmonella and E.coli and had too many coliforms, only one borehole did not have any growth.

Case Management

The most common symptoms suffered by the interviewed cases were fever (66.4%), headache (58.5%), diarrhea (47.9%) and abdominal cramps (67.8%). Ciprofloxacin, and Rocephin were used for case management based on drug sensitivity results. Erythromycin suspension was used for management of paediatric. Intravenous fluids and oral rehydration solution were also used as needed. No complications were reported. Patients were discharged from hospital on average of 3 days. Stool and blood specimens were collected to isolate the salmonella typhi and most laboratory forms were incomplete resulting in samples being thrown away. A Para-check was done in all patients with fever to rule out malaria to prevent misdiagnosis. Health education was also done to all patients on typhoid causes and how to prevent contracting typhoid and the importance of drug compliance to reduce incidences of drug resistance which is now a phenomena in other suburbs in Harare, contact tracing and follow up of cases was also done.

Outbreak Response

The district response was good in terms of notification, concrete response and the index case was reported on the 25th of December and the response was done on the 26th December, though there were outlier cases which were reported on the 22nd of October. There is need to improve on the timeliness of updating line lists.

The district established operational response teams at the district level. At the beginning of the outbreak, the district was operating mobile teams covering surveillance, health promotion and contact tracing.

A treatment camp was set up at Mbare Polyclinic on the 28th of December 2016. The following activities were conducted: treatment of suspected cases, specimen collection,

home/environmental assessment, active case finding and dissemination of information on typhoid.

Door to door health education on typhoid prevention and control was started in Mbare, initially by Health Promoters (HPs) from the City health department and was later complemented by partners such as MSF, Oxfam and Welt Hunger Hilfe. Resources were mobilized and MSF offered a vehicle to ferry patients to Beatrice road infectious disease hospital were critical cases were admitted.

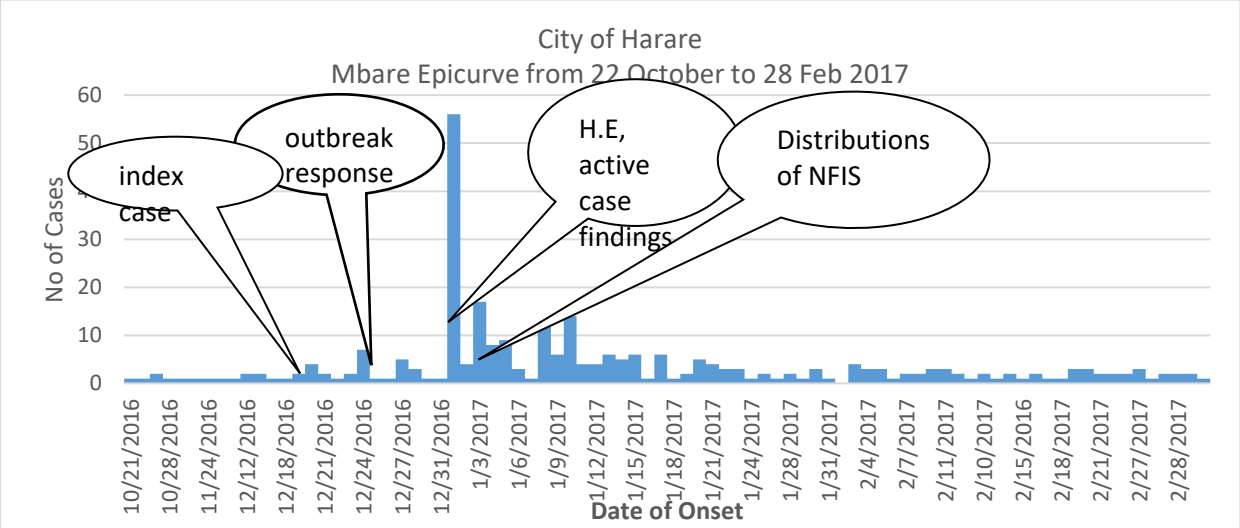
Water samples were taken from boreholes and municipal taps. Sewer bursts were also found to be a constant phenomenon, and blocked drains as well.

Aqua tabs, water guard, soap for handwashing were distributed to 9634 households, and taped water buckets were also distributed to vendors and schools. Burst sewer pipes were repaired or replaced. Contaminated boreholes were decommissioned. Municipal water supply was improved almost after the outbreak had been declared.

Description of the Outbreak by Time

Interpretation of epidemic curve shows that the general shape of the epidemic curve is that of the intermittent common source (point source) though there were outlier cases during the incubation period. This means that the exposure of the cases to the causative organism of typhoid was from a common source. This type of exposure produces a regular epidemic curve due to the intermittent and prolonged duration of exposure as seen in Epi curve below (figure 2). The peak of the outbreak was reached once, that is on 2nd of January, 2017. The peak period that is the 2nd of January 2017, goes hand in hand with the incubation period of typhoid which is 7 to 14 days (two weeks), which could suggest that the likely date of exposure prior to the peak of typhoid outbreak was in December, 2016. It is however difficult to know when the beginning of the outbreak earliest case occurred, because the epidemic curve is not clear on that, since there were outlier cases which occurred on the 22nd of October 2016 with other confirmed cases where reported in Mbare.

Figure 2: Epidemic curve of typhoid cases in Mbare 22nd October to 28 February 2017.



Preparedness and Response by the Southern District in Harare City Health Department

The outbreak response by District Health Executive was acceptably good and this is highly commendable. The only delay was the report made to the City Health Department. The Southern District health response team started investigations on the day they were notified about the death of a teenage girl who was a suspected typhoid case who had only Widal test done and no blood culture test done.

Evaluation of Outbreak Response

Table 5: Analysis of Southern district typhoid outbreak response, Mbare, 2017

ACTIVITY	TARGET	ACHIEVEMENT	COMMENT
OUTBREAK Interval between 1st case at community level to arrival of 1st outbreak case at health facility	24 hours	2 day	Target not achieved
Interval between 1st outbreak case seen at health facility and reporting to DHE and PHE	Within 24 hours	48 hours	Target achieved
OUTBREAK INVESTIGATION Interval between notification of district and field investigation conducted	Within 24 hours	24 hours	Achieved
Interval between sending specimen to lab and receipt of results	3-5 days	5 days	Achieved
OUTBREAK RESPONSE Interval between notification to district and concrete response	Within 48 hours of	48 hours	Achieved

Discussion

In this study, drinking untreated contaminated borehole water, poor sanitation, having a sewer burst near household and eating at a gathering were the major factors associated with contracting the disease. This is consistent with a study done in Indonesia which showed that sanitation and water play a central role in the transmission of typhoid [12]. The findings of the study revealed an association between several risk factors and the development of typhoid fever in Mbare at 95% CI. P-value = 0.05. Not having a facility for hand washing after toilet use had a higher association for contracting typhoid with an OR of 2.6. The association established was statistically significant (P= 0.023). Having hand washing facility was also found to be a protective factor against contracting typhoid in this study.

These findings imply that mostly borehole water which the majority of people used as a source of water for drinking was contaminated. These findings are in agreement with the study done by King, (2013) in Chu-Tung Township, Taiwan where the findings revealed that contaminated water was a source of the outbreak. Therefore policy makers should intensify the water treatment at point of use, rehabilitation of contaminated boreholes, setting up of inline chlorination and environmental sanitation measures in communities whose main source of water is from the boreholes. This would help to reduce the fecal-oral route of transmission of diseases such as typhoid.

Another factor to the common exposure such as lack of hand washing after toileting, and using water from the borehole after toileting, which seemed to have been contaminated, in which most people in Mbare were exposed regardless of having a working toilet or not. However, emphasis should be made by the relevant authority on rehabilitation and use of toilets in the area, which was found to be very low because most residents are supposed to use communal toilets, but the toilets are filthy dirty and flush system are dilapidated and they will end up not using the toilets and risk of contamination of the ground, and contaminated water sip into the ground, since most boreholes were shallow.

These findings however are similar with the findings of the study done by Muti et al 2011 in Dzivarasekwa Suburb of Harare City in Zimbabwe where it was found that water from a well was associated with typhoid (OR 6.2). Since there was shortage of water in Harare suburb of Dzivarasekwa, people relied on water from shallow wells which were downstream from sewer flows when there were sewer blockages, and water was contaminated with faecal coliforms and E. Coli as revealed by laboratory tests [15]. In the setup of Mbare where people also relied

on water from the contaminated shallow boreholes for drinking water, since there was shortage of water in Mbare, and also people perceived that borehole water was clean from the health education they had received in 2013 when the boreholes were drilled.

The use of wide mouthed containers for storing water was a risk factor to contracting typhoid and this is biologically plausible given the likelihood of contaminating water when getting it out of the container using another container which may not be clean or hands accidentally dipping in the container hence contaminating the water.

The majority (56%) had not attended health education on typhoid before 2016. Lack of health education in any set up could result in serious disease burdens and outbreaks. Basic information of any disease such as definition, etiology, transmission and prevention is important to reduce the incidence and prevalence of diseases.

In a study done in Indonesian, crowding (defined as >6 household members) was identified as an independent risk factor associated with contracting typhoid fever. During household visits and environmental assessments it was noted that at the epicenter of the outbreak there was overcrowding. More than two households were noted to be residing in one housing unit. This, coupled with poor water supply and poor sanitation, could have fueled the outbreak [14].

Having a typhoid contact in this study was not a statistically significant risk factor and this is also supported by the field epicurve which illustrates a point source outbreak, an indication of common source infection.

The relationship between having a typhoid contact at home and contracting typhoid may also have been insignificant in this study because of the health education done during clinic visits and roadshow which may have introduced knowledge on typhoid prevention and hence no secondary contamination, and the results are not consistent with results from a study by Madembo et. al were having a typhoid contact at home was a significant risk factor for contracting typhoid on factors associated with contracting typhoid in Mabvuku suburb of Harare. Females tend to be caregivers of those who are ill at home so if someone fell ill with typhoid, they were more likely to have more contact with females in the household as they were cared for during the illness [17]. Thus why there was higher likelihood of spreading the disease if appropriate hygiene practices were poorly observed.

In this study, a significant number of boreholes were positive for E. coli, salmonella and numerous faecal coliforms but this was not surprising as there were sewer flows everywhere

because of frequent sewer blockages and heavy rains as well which aided in water sippage to the ground, and facilitated flow of sewer to boreholes which had no apron and poor man ship during the time of study.

At the epicenter of the outbreak, in Mbare national 5th to 9th street, there was erratic water supply and in some households there was no water supply at all because of clogged pipes due to ageing and other technical faults. As a result residents did not have potable water for household use and were buying water at a private borehole for $0.20 a bucket. Another study by Gasem et al. showed that low socioeconomic status, poor housing with inadequate water supply and open sewers and inappropriate personal hygiene were associated with increased risk of contracting typhoid [12].

Sixty-eight (68%) of the cases interviewed reported or had a record of fever as one of the symptoms they were suffering. This is contrary to the fact that fever was one of the symptoms that was used for screening patients at Mbare Poly Clinic. Thus there was poor recording of the symptoms. Records review also showed discrepancies in symptoms recorded on the line list and those recorded on the case notes kept at the referral hospital.

More female controls were interviewed compared to males. This is likely because females were more likely to be at home when interviewer visited the household. More cases than controls knew the symptoms of typhoid probably because they had suffered one or more of the symptoms. The lack of significant differences in knowledge of most of the variables could be due to the door to door education conducted during the outbreak [14].

At the health centre level, Mbare poly clinic, stool specimens were being collected from both cases and contacts. A transport system was put in place where specimens were collected 3 times a day from the clinic to the laboratory. There was however concern on the possibility of delay in transporting specimens to the laboratory resulting in low isolation rate (30 *S typhi* positives out of 242 suspected cases). There was also a possibility that some positive cases could have been missed as mostly people would have taken some medication before they report to the clinic, and hence fever which was the main symptom for one to be line listed end up not line listed and hence some bias could have been introduced. Para check was also done to patients with a fever to rule out malaria and ensure only typhoid fever is being treated.

Strong evidence exists that fluoroquinolones are the most effective drugs for treatment of typhoid fever, with cure rates exceeding 96%. The review on typhoid also showed that third generation cephalosporins such as ceftriaxone, and azithromycin are also effective drugs for

treating typhoid [18]. In this study, cases were being managed with ciprofloxacin as the antibiotic of choice based on drug sensitivity results. Rocephin and paracetamol were administered based on need and erythromycin suspension was used for paediatrics.

The availability of an Epidemic preparedness and Response team which included all relevant stakeholders helped to speed up response of the outbreak. The team had regular updates during the outbreak such that they were prepared for outbreak and the reaction was good even though it was the festive season holidays.

The reasons raised by residents for rating the WASH situation in Mbare as poor especially flats that include, Shawasha, Matapi and Nenyere flats could justify the existence of typhoid in Mbare since they provide conducive environment such as raw sewage is always dripping from the flats for the propagation of the microorganism that cause typhoid. The participants outlined several responses on how typhoid is transmitted. These responses are typical of inadequate information among participants in relation to good health practices, which can be achieved through health education and promotion. Even those who provided the right information, possibly it was due to education campaigns that were conducted in the area soon after the outbreak had occurred. This being a retrospective study, education had an influence on the findings on this question, because these are the very same participants who indicated that they had never had any health education on typhoid prior to the outbreak as discussed above.

Conclusion

In conclusion, poor water and sanitation was associated with the typhoid outbreak. Boiling water and the use of narrow mouthed water containers for water storage was a protective factor. The most important risk factors associated with contraction of typhoid were using contaminated water from a borehole, and lack of hand washing facility after toilet use. This was a point source outbreak and is supported by the incubation period which was suggestive of common contamination from contaminated boreholes due to sewer sippage into the poorly constructed boreholes.

Recommendations

Measures need to be put in place by the City Health Department in order to avert any further typhoid outbreaks in Harare. On the background of repeated occurrences of typhoid outbreaks in the greater Harare the following should be done:

- Water monitoring of water source should be done regularly to ensure provision of wholesome palatable water supply. [DEHO]
- Installing inline chlorinators and chlorinators to be replenished and maintained regularly. [Harare Water]
- Availability of water supply to all residents. [Harare Water]
- Health education on the importance of water treatment at point of use. [DHPO]
- Health education on water storage and importance of handwashing always. [DHPO]
- Replacing old sewer and water reticulation pipes. [DO]
- Refuse collection need to be done consistently.[DO]

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