FACTORS ASSOCIATED WITH THE 2012 TYPHOID FEVER OUTBREAK IN MUFULIRA DISTRICT, ZAMBIA: A CASE CONTROL STUDY

Outbreak Report

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Typhoid fever is still a public health concern especially in Africa and Asia infecting millions of people while killing thousands. In the year 2012, Zambia recorded a number of typhoid fever outbreaks. The most affected being Mufulira district in the Copperbelt province. As risk factors for typhoid fever may differ from one area to another, determination of risk factors for typhoid fever outbreak is critical in the formulation of rational setting-specific control and preventive measures. We investigated factors that were associated with the typhoid fever outbreak in 2012 in Mufulira district, Zambia. A case control study was done to determine factors associated with typhoid fever infection in Mupambe. All 42 cases meeting the inclusion criteria where invited to take part in the study while controls where selected by simple random selection from eligible members of each selected household. To select households for controls, every third household was picked by systematic random selection from the total of 450 household. Individual association of possible risk factors and typhoid fever infection where first analysed using logistic regression. Risk factors with the p value of less than 0.2 were then examined using multivariate logistic regression. The final model was assessed using Pearson's Chi-square diagnostics. A total of 36 cases and 138 controls participated in this study. Age, younger than 23 years (aOR: 4.64, 95%CI: 1.84, 11.71), eating food from street vendors more than 7 times /week (aOR: 3.83; 95%CI: 1.40, 10.50), eating vegetable salads more than 2 times / week (aOR: 4.82; 95%CI: 1.63, 14.22) and drinking untreated water (aOR: 4.56, 95%CI: 1.73, 12.14) were significantly associated with typhoid fever. Eating of unsafe food and personal hygiene were factors responsible for the typhoid fever outbreak, suggesting that sensitising the community on good hygiene practices and general cleanliness could prevent further recurrences. Hygiene, Outbreak, Risk factors, Typhoid, Zambia

Introduction

Typhoid fever, the disease believed to date as far back as 424 BC is still responsible for 216,000 to 600,000 deaths and 12 to 33 million cases annually, mostly in Africa and Asia [1-4]. Outbreaks of the disease have been recorded in many African countries, like Malawi, Mozambique, Uganda and the Democratic Republic of Congo [5-7]. Typhoid is an enteric fever caused by the gram-negative bacilli called Salmonella enterica commonly known as Salmonella typhi, and the age group 5 to 17 years has been shown to be the most affected [8,9]. Since the disease is exclusively a human infection, its transmission is therefore through water or food contaminated by faeces or urine of an infected person. Water gets contaminated when raw sewage finds its way into a water source or through unhygienic handling of water by an infected individual. This could be due to a lack of proper toilet facilities, poor collecting and treatment of raw sewage or poor general hygiene practiced by the community [10-12]. The disease can be prevented through provision of adequate and safe water [11,12]. Therefore, boiling or chlorination of water and proper storage has been recommended in a number of studies for typhoid fever prevention and control [10,12,1314]. Food gets contaminated through unhygienic handling by an infected individual, flies, washing fruits or vegetables in contaminated water and watering of gardens with raw sewage. Unlike in water, the bacilli can multiply in food to the required infective dose [10,11]. Although a number of risk factors and population subgroups at higher risk are known, previous studies have also shown that different settings may have different risk factors for typhoid fever depending on differences in culture, social and economic factors and whether the disease is endemic in a specific area or not [10,12]. Improving the social profile of any community or where this is limited, the knowledge of risk factors associated with the disease in the local setting is therefore cardinal in the formulation of rational control and preventive measures. Although more than 50% of the 2012 typhoid cases in Zambia were recorded from Mufulira [15], no study has been done yet to critically determine factors that were associated with it. The study reported in this article therefore determined the risk factors that were associated with the outbreak.

Methods

A case control study was done in Mufulira, a mining district in the Copperbelt province of Zambia. Mufulira covers a total surface area of 1,258 square kilometres. There are two government hospitals and one mine hospital servicing the district, together with a number of health posts. The urban part of Mufulira District is serviced by the Mulonga Water and Sewerage Company. A non-matched community-based case-control study was done in Mupambe Township to investigate risk factors that were associated with the typhoid fever outbreak. Mupambe was chosen because it recorded more than 90% of the cases in Mufulira [16]. The township is located 5 kilometres from Mufulira town centre. It had a total population of about 3,000 with 450 households. All household in Mupambe were serviced by Mulonga Water and Sewerage Company. The old and damaged sewer and water pipelines, which run next to each other from the main water pump to the township, were the suspected source of infection.

During the pilot study to test the questionnaire for this study, the proportion of drinking untreated municipal water was found to be 0.7 among cases and 0.4 among controls. Using these proportions, a 10% non-response and the ratio of 1 case to 3 controls, a sample size of 42 cases and 129 controls was needed for this study at 80% power and 95% confidence level. In this study, Cases were defined as residents of Mupambe during the outbreak, aged 10 years or older, and having been confirmed with laboratory test as positive for Salmonella typhi. Controls were defined as residents of Mupambe during the outbreak, aged 10 years or older who were not diagnosed with typhoid fever during the outbreak. Those below the age of 10 years or who were for any reason not able to give a valid consent were excluded from the study. All 42 cases meeting this case defination were invited to participate in the study. To select controls, every third household in Mupambe was selected by systematic random selection from a total of 450 household. A control was then selected from each selected household by simple random selection from household members meeting the inclusion criteria.

Data collection & analysis

Two nurses trained in data collection procedures collected information on demographics (2 variables) and potential exposure (14 variables) from both cases and controls using a pretested structured interview schedule (Table 1). Exposure period was defined as 21 days before typhoid fever onset for cases and during the outbreak for controls. Data was then entered into Epi-data version 3.1 before it was exported to Stata version 12 (StataCorp, College Station, TX, USA) for analysis. A p-value of 0.05 and below was considered statistically significant. Univariate analyses using logistic regression were done to determine associations between typhoid fever infection and individual exposures. All variables from univariate analysis with p-value of less than 0.2 were then included in multivariate logistic regression analysis to determine their unconfounded association with typhoid. The final model was identified while possible interactions were checked using backward stepwise regression procedures. Pearson's chi-square diagnostics were employed to assess the goodness of fit of the model.

Ethical consideration

The protocol for the study was approved by the Biomedical Research Ethics Committee of the University of Zambia (REF.NO: 004-03-13). Written permission to carry out the study was also obtained from the Zambian Ministry of Health and Mufulira District Medical Office. The objectives, method, risks and benefits of the study were explained to participants and written consent was obtained before the interviews were conducted for those aged 18 years and older. Those who were below the age of 18 years signed an assent form while their parents consented. Participant identification was done using serial numbers to ensure anonymity and thus confidentiality.

Results

Participation and distribution

All the 42 eligible cases were invited to participate in the study. However, of these only 36 cases accepted and these were matched with 138 controls (males 70, female 104). The main reasons for non-participation were refusal 2 (1.1%), lack of suitable control in a selected household 9 (5.2%) and absence due to migration 4 (2.3%) and house found to be occupied by new families 3 (1.7%).

Table 1. Exposure variables.

Exposures	Indicators	Scale of measurement
Eating habits	During the outbreak, how many times per week did you eat the following? Eating food from vendors Eating vegetable salads Eating fruits Eating cold cooked food	Frequency per week.
Household treatment of drinking water	During the outbreak, how many times out of ten would you say you drank untreated water	0- Never 10- Always
Hand washing habits	Out of ten how often did you fail to wash your hands during the outbreak i. Before eating food. ii. After visiting the toilet. iii. Before handling drinking water. iv. After handling baby's nappies. v. With soap	0- Never 10- Always
House hold Sanitary conditions	Did you have the following in your household; i. Soak away ii. Blocked sewer iii. Broken sewer	Yes /No

Table 2. Univariate analysis of factors associated with the 2012 typhoid fever outbreak in Mufulira Zambia.

Risk factors	Cases Odds (n=36, %)	Controls Odds (n=138, %)	OR (95% CI)	P-value
Demographic information				
Age (<23 years)	2.27 (25, 69)	0.53 (48, 35)	4.26 (1.93-9.40)	0.001
Sex (female)	1,77 (23, 64)	1.42 (81, 59)	1.25 (0.58-2.66)	0.572
Eating habits				
Eating food from vendors more than 7 times/week	3.00 (21, 58)	0.82 (62, 44)	3.31 (1.55-7.06)	0.002
Eating vegetable salads more than 2 times/week	4.14 (29, 81)	0.68 (56, 41)	6.07 (2.48-14.81)	< 0.001
Eating fruits more than 7 times/week	0.80 (16, 44)	0.33 (34, 34)	1.55 (0.73-3.27)	0.250
Eating cold cooked food more than 5 times/ week	0.80 (16, 44)	0.21 (24, 17)	3.80 (1.72-8.38)	0.001
Treatment of drinking water				
Drinking untreated water all times all times	2.60 (26, 72)	0.60 (52, 38)	4.30 (1.92-9.63)	< 0.001
Drinking treated more than 4/10 times.	11.00 (33, 92)	2.14 (94, 68)	3.58 (0.15-0.68)	0.005
Hand washing habits				
Not washing hands before eating food more than 2/10 times	1.25 (20, 56)	0.57 (50, 43)	1.63 (0.29-1.29)	0.198
Not washing hands after visiting the toilet more than 2/10 times	3.00 (27, 75)	0.89 (65, 47)	3.37 (0.13-0.68)	0.004
Not washing hands before saving drinking water more than 4/10 times	1.00 (18, 50)	0.47 (44, 32)	2.14 (0.22-0.99)	0.046
Not washing hands after handling baby's nappies more than 6/10 times*	0.33 (9, 56)	0.29 (31, 22)	1.37 (0.24-2.20)	0.577
Not washing hand with soap	0.71 (15, 42)	0.29 (31, 22)	2.47 (0.19-0.88)	0.022
Sanitary conditions				
Presence of blocked sewer-line	0.80 (16, 44)	0.89 (65, 47)	0.90 (0.43-1.88)	0.776
Presence of broken sewer-line	2.27 (25, 69)	1.56 (84, 61)	1.46 (0.66-3.21)	0.345
Presence of soak-away	6.20 (32, 89)	6.26 (119, 86)	1.28 (0.41-4.02)	0.676

**Had total sample size of 80 (16 cases and 64 control) as the variable wasn't applicable to those without babies and most men.*

Table 3. Multivariate analysis of factors associated with the 2012 typhoid fever outbreak in Mufulira, Zambia.

Demographic information				
Age (<23 years)	25 (69)	48 (35)	4.64 (1.84-11.71)	0,001
Eating habits				
Eating food from street vendors more than 7 times/week	27 (81)	62 (44)	3.83 (1.40-10.50)	0.009
Eating vegetable salads more than 2 times/week	21 (58)	41 (30)	4.17 (1.43-12.18)	0.009
Treatment of drinking water				
Drinking untreated water all the time	26 (72)	52 (38)	4.14 (1.60-10.68)	0.003
Hand washing habits				
Not washing hands after visiting toilet more than 2/10 times	27 (75)	65 (47)	0.69 (0.26-1.78)	0.430
Sanitary conditions				
Presence of broken sewer in a household	25 (69)	84 (61)	2.27 (0.90-5.74)	0.083

Predictors of Infection

The main predictors of typhoid infection in univariate analysis were largely driven by eating of unsafe food, particularly eating vegetable salads. Those who ate salads more than 2 times/week were six fold more likely to contract typhoid infection than their counterparts who didn't eat the salads (P<0.001). In addition, the likelihood of infection was higher among those who always drunk untreated water, ate cold cooked food more than 5 times/week, ate food from street vendors more than 7 times/week and those who did not wash hands with soap after using the toilet (Table 2). On the other hand those who washed their hands after visiting the toilet were 2.4 times less likely to have typhoid than their counterparts (P=0.004). Furthermore, those below 23 years of age were three times more likely to have typhoid fever infection than those who were older (P=0.001). In multivariate analysis (Table 3), those below 23 years of age had higher likelihood of infection than the older ages (aOR 4.64 95%CI: 1.84, 11.71). Other predictors of infection were eating food from street vendors more than 7 times/week (aOR 3.83 95%CI: 1.40, 10.50); eating vegetable salads more than 2 times/week (aOR 4.17 95%CI: 1.43, 12.15) and drinking untreated water (aOR 4.14 95%CI: 1.60, 10.68).

Discussion

We found combined evidence of both poor individual hygiene and sanitary conditions to be the main factors associated with typhoid infection outbreak in this district. Although this may be expected in such poor environments [4,10,13,14], the presence of obvious preventable factors which seem to have been working in synergistic manner was alarming but could suggest a breakdown in basic community sanitary conditions. In the absence of locally based data on factors associated with typhoid fever outbreak in this country (Zambia), findings in this study can be a proxy of potential predictors of infection in other districts where similar outbreaks have been reported.

In this population, we do not have a good explanation as to why the typhoid infection was higher in the under-23-year-old group compared to those who were 23 years old or older. However, we have noted that similar studies have reported the age group 5 to 17 years as the most affected in similar conditions [8,9,12,13]. Nonetheless, we observe coincidentally that this is a predominantly school going age in this population. Since there was no treated drinking water made available by the school in the area, this age group was likely to drink untreated water straight from taps thereby increasing exposure to the infection in general. Furthermore, they were also more likely to buy food from vendors during break-time as street vendors were allowed to sell at the school entrance without proper sanitary conditions. These combinational factors could explain in part the differential infection patterns by age groups which was not different by sex.

The implication of faecal-contaminated water as the source of infection in poor resource setting has historically shown how faecal-oral route remain the main route of infection suggesting that effecting control either at water safety point or at the personal hygiene point could effectively control such an outbreak. Similar studies in Karachi [10] South Dumdum, India [13], and Uzbekistan [11] also implicated untreated contaminated water as a risk factor for typhoid fever transmission. This could be because water does not stay long enough in the stomach for the gastric acids to act in the destruction of all the bacilli.

Eating food from street vendors was also found to be significantly associated with typhoid fever in the current study. These findings are similar to those found in West Bengal, India [18] and Jakarta, Indonesia [19]. Street vendors especially in lower-class residential areas, like Mupambe, have no proper toilet facilities to use, open defecation is thus the likely way out. This, together with lack of facilities for proper storage of the food they sell, increases the chances food contamination. Also their customers usually have no facilities to wash their hands before eating the food they buy from these vendors. This could explain why eating food from vendors is associated with typhoid. Salmonella typhi also multiplies in food, thereby increasing the number of bacteria per unit volume of food even if the initial dose was below the minimum infective dose. In line with the findings by Sharma et al. [18] and Srikantiah et al. [11], the current study found that eating vegetable salads was another risk factor significantly associated with typhoid infection. Vegetable gardens were found around the area where the sewer line was broken during the outbreak. It is very likely therefore that raw sewage was being used to water these vegetables, which could have led to their contamination. Even within some houses in Mupambe, raw sewage was seen to be overflowing. This contaminated water could easily find its way into the surrounding vegetable gardens. These factors may therefore explain why eating vegetable salads was a risk factor. These findings do not just underscore the role of personal hygiene in the control of such outbreaks, but they also illustrates past limitations in personal hygiene health promotion messages or programs as the main stay in preventing such outbreaks still troubling poor communities. When this is coupled with structural responses such as the provision of safe piped water where prevention maintenance is a public health good, such outbreaks should never occur. This together with integrated environmental outreach programs managed at district level has the potential to improve lives of poor people and likely to prevent associated early and painful deaths of apparently health populations.

Conclusion

The objective of the study was to investigate the possible risk factors associated with the Mufulira typhoid fever outbreak. The study demonstrated that the outbreak was propagated through drinking untreated municipal water, eating raw vegetables and eating food bought from street vendors. This suggested the need to sensitise the communities on the importance of good hygiene practices and general cleanliness. The monitoring of water safety and disease surveillance structures remains a responsibility of district officers who have an ethical duty to make these decisions. The disease surveillance systems must not just focus on checking microbiological contamination, but drug sensitivity patterns, behaviour patterns of people, as well as continued social mapping of the population so as to know the exact demographics of any such population. This will avoid the possibility of an outbreak of diseases arising as a result of multi-drug resistant strains of typhoid. We conclude by calling on the responsible line ministries to work with local authorities in improving the sanitary conditions of communities within their catchment areas. In addition, there is need to integrate personal hygiene messages in all health promotion messages. Lastly but not the least, there is urgent need to examine the efficiency of local surveillance systems in not just preventing and controlling such outbreaks, but in generating health intelligence information which should be critical to adjust strategic responses for disease control and prevention.

Authors' contributions

PS was responsible for the conception and design of the study, and collected data for the case control study. He also did the data analysis, interpretation and the drafting of the manuscript.

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