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Association between Environmental Factors and Typhoid Fever Post Massive Flood in Northeastern Malaysia

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Abstract: Typhoid fever, an acute systemic enteric disease caused by *Salmonella typhi* remains a public health burden around the globe. In December 2014, a massive flood hit northeastern Malaysia causing negative impacts on the physical infrastructure resulted in environmental disruption that favoured disease transmission. The present study was conducted to determine if there was an association between environmental factors and confirmed typhoid fever post massive flood in northeastern Malaysia. A cross-sectional study was conducted using simple random sampling to select 393 cases from all the notified typhoid fever cases in 2015. Those cases with positive blood, urine or stool culture were considered as confirmed typhoid fever. Multiple logistic regressions analysis was applied to examine the association between environmental factors and confirmed typhoid fever following the massive flood. P-value of less than 0.05 was judged to be statistically significant. It was found that the proportion of confirmed typhoid fever among the notified cases was 14.2%. Students and age-group of 11-20 years old contributed the highest number of the confirmed typhoid fever post massive flood. Environmental factors that were found to be associated with confirmed typhoid fever post massive flood were non-treated water supply (Or_{adj} 3.54, 95% CI 1.91-6.54), inadequate wastewater management (OR_{adj} 3.03, 95% CI 1.55-5.89) and non-residential type of house (OR_{adj} 2.95, 95%CI 1.31-6.64). In conclusion, the collapse of infrastructures following a massive flood caused environmental disruption that led to lack of hygiene and sanitation. The condition provides a suitable environment for typhoid fever transmission. Hence, an appropriate intervention is highly recommended to those hit by the disaster to prevent typhoid epidemic.

Key words: Typhoid Fever · Massive Flood · Environmental factors

INTRODUCTION

Flood event is the most occurrence of natural disaster worldwide and accounts for 40% of natural disaster worldwide [1, 2]. Flood and climate change may cause a negative impact on the economy, physical infrastructure, cultivation and livestock [3] as well as disruption to the environment. The analysis from a previous study demonstrated that the property is the most affected by the flood [4].

Due to its location, northeastern Malaysia experiences monsoon flood as an annual natural disaster with a varying degree [5]. In December 2014, it experienced one of the worst flood ever recorded in history and considered to be a tsunami-like disaster.

Typhoid fever is an acute systemic enteric disease, often life-threatening febrile illness caused by *Salmonella Enterica Serovars Typhi* and transmitted via the fecal-oral route. It remains a public health burden around the globe particularly in developing country in which transmission commonly occurs where there are inadequate sewage disposal and flooding [6]. A previous study revealed that nearly 45% of people were affected by this disease at least once in their life [7]. Comparing between males and females, the risk to get the disease were 42 and 48% respectively [8].

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A massive flood that hit northeastern Malaysia in December 2014 led to infectious disease outbreaks which resulted in substantial population displacement and exacerbate synergic risk factors such as a change in the environment and human conditions such as lack of clean water supply, damage to septic and wastewater management resulting in the vulnerability to existing pathogens for disease transmission [9].

Following the massive flood in December 2014, there is an increase of incidence rate of typhoid in 2015 up to 10.6 over 100 000 populations, which was 10 times above national level and median five years incidence rate. Changes in human conditions, the ecosystem of pathogens and environment facilitate the occurrence and transmission of infectious diseases [10]. This could be due to the prolonged after effect and change in the environment after the flood which led to the epidemic.

Several studies reported that typhoid fever is likely to occur after the flood [11-13]. The mechanism of how flood leads to an increase in infectious diseases, including typhoid fever could be due to the environmental modification post-flood. However, there is limited study describing environmental factors post-flood that lead to increased incidence of typhoid fever. A better understanding of the underlying mechanism and association between flood and increased incidence of typhoid fever post-flood will support the evidence-based flood policy and mitigation strategy. Hence, the present study was conducted to determine the proportion of confirmed typhoid fever cases and its association with socio-demographic characteristics and environmental factors post the massive flood.

MATERIAL AND METHODS

Study Design and Respondents: A cross-sectional study was conducted in all districts of northeastern Malaysia which are mostly populated by Malay ethnicity followed by Chinese, Siamese and Indian. Due to its geographical location which is adjacent to the coast of the South China Sea, it experiences monsoon season every year which results in a flood with varying degree of severity.

The source population was all patients with fever who were notified as typhoid fever to the State Health Department from 1st January 2015 to 31st December 2015. The largest and feasible sample size was calculated using a single proportion formula based on a study conducted by Vollard *et al*. [13] who reported the proportion of confirmed typhoid fever among the high-risk group as 0.31. The confidence interval was set at 95% and the precision of the study as 0.05. The required sample was 393 after considering 20% of the non-response rate. A simple random sampling was applied to select 393 respondents from a total of 1266 notified typhoid fever cases.

Data Collection and Research Tool: All notified typhoid fever cases from 1st January 2015 until 31st December 2015 was obtained from E-notification online system (CDCIS E-Notifikasi Version 2011.1). This is an online national surveillance system which was developed by the Ministry of Health of Malaysia. All informations for socio-demographic and environmental variables were obtained from the Food and water-borne disease investigation form (FWBD/UMU/BG/007) which was kept in all district health offices.

All information was collected using a checklist proforma. Data was transformed into Microsoft Excel and exported into Statistical Packages for the Social Sciences (SPSS) version 22 for statistical analyses.

Definition of Operational Terms: A confirmed case of typhoid fever was defined as a person with a positive culture of *Salmonella Typhi* from blood, urine and stool. Venous blood of 5-10 mL was collected from the patients and put into a sterile bottle which may yield 90% positive culture for the first week and 50% positivity for the third week. Stool culture and high rectal swab were also taken and tested within 24 hours after sample collection [9].

The proper toilet was defined as flush toilets, toilets that pour or flush to pit latrines, ventilated improved latrines and pit latrines with slabs. Whereas, the improper toilet was defined as traditional latrines, pit latrines without slabs and shared latrines [14].

For the type of house, residential is a systematic structure house with facilities whereas non-residential house was the one with no systematic structure in the way the houses were built, lack of public facilities and the houses being in poor repair [15].

A proper septic tank referred to a watertight chamber sited below the ground level, receiving excreta and flush water, lined with bricks or concrete. Any breaks of the chamber were considered as improper septic tank [16].

Adequate wastewater management is defined as wastewater generated from households or premises channelled away through special pipes in mannered not to pose danger and health problems to the environment and man. Any breach of it was considered as inadequate wastewater management [16].

Statistical Analyses: Descriptive statistics were used to summarise the socio-demographic characteristics of subjects. Categorical data was presented as frequency (Percentage). Meanwhile, numerical data was presented as mean (SD) or median (IQR). Multiple logistic regressions analysis was applied to examine the association between environmental factors and confirmed typhoid fever following the massive flood. In multiple logistic regression analysis, variables selection was based on clinical importance and biological plausibility. The manually selected variables were then analyzed using forward and backward LR methods. The preliminary final model was obtained after comparing the results from these two methods.

The assumptions of multiple logistic regression were checked. Multicollinearity was checked using the variance inflation factor (VIF). All possible two-way interactions were also checked. The fitness of the model was tested using the Hosmer-Lemeshow goodness of fit test, the classification table and area under the receiver operator characteristic (ROC) curve.

The final model was determined by the enter method. Findings were presented by the adjusted odds ratio (AOR), 95% confidence interval (95% CI) and *p*-value. The level of significance was set at a *p*-value of less than 0.05.

The confidentiality of the respondents was protected as no identifiable information was collected and any information was not exposed. In addition, only the researchers had access to the data. The data were stored in a password protected digital storage for three years and then will be archived. Ethical clearance approval was obtained from the Human Ethics Committee, Universiti Sains Malaysia and National Medical Research Registry, Ministry of Health Malaysia.

RESULTS

A total of 393 respondents involved in the present study. The age of respondents ranged from 1 to 94 years old with the mean (SD) age of 26.9 (20.8) years old. Most of the respondents were Malays. Table 1 shows the socio-demographic characteristics of the notified typhoid fever cases in northeastern Malaysia in 2015.

Out of 393 respondents, 56 of them were positive for *Salmonella typhi* by the culture of blood, urine or stool categorised as confirmed typhoid fever. Hence, the proportion of confirmed typhoid fever among the notified typhoid fever post massive flood was 14.2%.

From the simple logistic regression analyses, the variables selected to be included in the multiple logistic regression analysis were employment status, age group, type of housing, type of water supply, wastewater and waste management and presence of vector. Meanwhile, gender, ethnicity, type of occupation and type of toilet were excluded in the analysis as the p-values were more than 0.25.

Table 2 shows the factors associated with the confirmed typhoid fever post massive flood in northeastern Malaysia using multiple logistic regression analysis.

DISCUSSION

Among the notified typhoid fever cases, the present study found that the proportion male and female who contracted typhoid fever was almost equal. This is consistent with the previous studies which found that there was no significant gender distribution for typhoid fever [1, 17]. However, several studies found that males are more likely to be infected by *Salmonella typhi* due to

Table 1: Socio-demographic characteristics of notified typhoid fever cases in northeastern Malaysia in 2015 (n = 393)

Variables	Frequency, n (%)
Age Group	
Child (≤ 10 years old)	99 (25.2)
Teenager (11-20 years old)	98 (24.9)
Adult (21-60 years old)	163 (41.5)
Elderly (>60 years old)	33 (8.4)
Ethnicity	
Malay	383(97.5)
Others	10(2.5)
Gender	
Male	219 (55.7)
Female	174(44.3)

Table 2: Factors associated with confirmed typhoid fever post massive flood in Northeastern Malaysia using multiple logistic regression analyses (n = 393)

Variable	AOR (95% CI)	Wald stat (df)	P value
Type of house			
Residential	1.00		
Non-residential Area	2.96 (1.32, 6.64)	6.88 (1)	0.009
Water Supply			
Treated	1.00		
Non-treated	3.54(1.91, 6.55)	16.24 (1)	< 0.01
Wastewater management			
Adequate	1.00		
Inadequate	3.03(1.56, 5.90)	0.64 (1)	0.001

Hosmer Lemeshow test, p-value 0.071

Classification table 87.3 correctly classified

The area under Receiving Operating Characteristic curve was 74.7%

their outdoor exposure compared their counterpart [12, 18]. More than half of the confirmed typhoid fever cases were among those aged from 11-20 years old. This finding is in line with several other studies [12, 19, 20] which indicates their high mobilisation. Children and teenagers tend to play outside and lack of hygienic practice which predisposed them to the environment contaminated with *Salmonella typhi* compared to the adults.

The proportion of confirmed typhoid fever among notified cases post massive flood in northeastern Malaysia was higher compared to the findings from a study conducted in Vietnam [19] and Indonesia [21]. This finding demonstrates that in the presence of a suitable environment such as post-natural disaster such as flood, the proportion of confirmed typhoid fever is higher. Moreover, Mogasale, Ramani, Mogasale and Park [22] had mentioned that the true incidence of typhoid fever is likely to be underestimated as the blood culture sensitivity was only 66% compared to bone marrow culture result.

The present study showed that the environmental factors that are associated with typhoid fever were non-residential type of house, non-treated water supply and inadequate wastewater management. This finding reflects the damage to the clean water and sanitation infrastructure following a massive flood as the main environmental modification that leads to an increase in a number of confirmed typhoid cases in northeastern Malaysia in the year 2015. A study on the impact of the flood on children and adult health and way to sustainable development supports the finding as flood leads to an unhygienic condition in the environment [23]. Massive flood displaced everything along the flow including buildings and many people were left homeless due to the destruction of the house.

The present study also demonstrated that those who live in the non-residential house have a higher risk to have typhoid fever. This is possible as non-residential houses are more vulnerable to experience damage due to the massive flood. As a result, the victims needed to be evacuated to the overcrowded shelters and live in a tent following the closure of the temporary shelters. A similar result was also obtained by a few other studies [24-26]. In the study, untreated water supply is also significantly associated with typhoid fever. It is in line with many previous studies which found that risk of typhoid fever is highest in the area which has a lack of treated water supply forcing the victims to look for unsafe water source [27, 28].

It was reported that during the massive flood, the victims needed to use flood water for domestic activities like cooking and bathing due to water shortage [29]. In addition, contaminated flood water can also cause surface and groundwater contamination [30] and it is known that *Salmonella typhi* manage to survive several months in water and soil [18]. Hence, contamination of groundwater may cause the water supply to be an environmental reservoir for disease transmission.

The present study also found that inadequate wastewater management was associated with typhoid fever post massive flood. As flood water might be contaminated by the overspill of the septic tank containing faecal material, it worsens the condition. Moreover, flood victims tend to defecate in the environment due to damage of toilet infrastructure and lack of treated water supply. When flood subsides, a remnant of the water will drain into the wastewater drain. In a setting where there was inadequate wastewater management, contaminated water will not be drain away. Hence, wastewater will become stagnant and harbour *Salmonella typhi*. This is supported by a report which

stated that flood victims who have inadequate wastewater management may have a higher risk to be affected by food and water-borne diseases including typhoid fever [31].

Environmental factors like type of toilet and septic tank were also important to be studied. However, those variables were dropped from the statistical analysis in the present study in view of imbalance between the groups. A study in Cambodia found that proper toilet is a protective factor against diarrheal disease following flood [11]. In the present study, inadequate garbage management was found to be not associated with typhoid fever. In contrast, a local study stated that inadequate waste management is the main cause of disease transmission [32].

All three environmental factors that are found to be associated with typhoid fever in this study are strongly related with the infrastructural damage following the massive flood. Therefore, a mitigation strategy for flood and other climatic events should also address strong infrastructural facilities to withstand damage, therefore, reducing the negative impact of the sequel. Disease control and prevention should also be prioritised at the schools rather than community alone. In term of the affected community, it is suggested to develop residential type of house which equipped with treated water supply and good wastewater management. Residential house is less likely to sustain damage of infrastructure compared to the non-residential house following the flood. Therefore, water sanitation and hygiene will be less affected which may reduce the risk of diseases transmission following the flood. Lastly, it is recommended to study other environmental factors such as elevation level, distance to water bodies as well as personal hygiene which may relate to the disease transmission in the future.

CONCLUSIONS

There is an association between socio-demographic characteristics and environmental factors with typhoid fever post flood 2015 in Kelantan. This study showed that children and adolescents contributed the most for typhoid fever during post massive flood 2014.

The environmental variables that are associated with typhoid fever post flood were non-residential type of house, non-treated water supply and inadequate wastewater management. Those factors are closely related to each other. This finding might explain the damage to water and sanitation infrastructure due to a massive flood that caused prolong after effect post-flood situation. The principles of clean water and proper sanitation remain vital elements in preventing food and water-borne diseases including typhoid fever.

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