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Factors associated with typhoid fever in Western Nepal: A cross-sectional study

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Abstract

Introduction: Typhoid fever is one of the major public health problems in Nepal. This study aims to generate evidence for policy formulation for typhoid prevention and control by analyzing the role of some environmental and household characteristics as risk factors for typhoid fever in Western Nepal.
Methods: This was a cross-sectional study design using a household survey data of Western Nepal. In-depth in-person interviews were conducted using semi-structured questionnaires for data collection. Probit/logistic regression models were used to gauge the factors affecting typhoid occurrence.
Results: Probit/logistic regression results indicated that extreme winter temperatures (aOR = 2.22; 95% Confidential Interval (CI) 1.15 to 4.28), river water pollution (aOR = 2.11; 95% CI 1.18 to 3.78), decreased shrub cover including medicinal plants (aOR = 2.32; 95% CI 1.32 to 4.06) and less exposure to heat waves (aOR = 0.36; 95% CI 0.16-0.81) are the major environmental factors likely to influence typhoid fever occurrence in Western Nepal. Besides, community awareness programs (aOR = 3.59; 95% CI 1.54 to 8.34) and hand washing with water and soap (aOR = 0.75; 95% CI 0.10 to 0.95) can influence the typhoid occurrence.
Discussion and Conclusion: An appropriate adaptation packages against the inextricable environmental factors at the community level is required together with replantation of medicinal and other shrubs surrounding the community. This research recommends formulation of policies and program for control of waterborne diseases addressing environmental factors with considering personal hygiene maintenance for the control of typhoid fever in Western Nepal.

KEY WORDS: Typhoid fever; environmental factors; household characteristics; Logistic regression; Western Nepal.

INTRODUCTION

Typhoid fever causes morbidity and mortality worldwide as a major part of the disease burden in developing and tropical regions, particularly in South Asia including Nepal [1]. Almost 80% of the global typhoid cases come from Bangladesh, China, India, Indonesia, Laos, Nepal, Pakistan and Vietnam [2, 3], where environmental hazards are increasing at alarming rate [4]. Epidemiologically, typhoid fever is most common in the underdeveloped areas of developing countries with incidence rate of 55 per 100,000 populations [5]. Typhoid fever globally infects roughly 21.6 million people (incidence of 3.6 per 1,000 populations) and kills an estimated 200,000 people every year [5]. With more than six thousand cases of typhoid with over a hundred deaths, Nepal is facing threats of typhoid as a major public health problem [6]. A bacterium *Salmonnella typhi* is the pathogen to cause typhoid, still maintaining 0.95% case fatality rate [7]. This bacterium mainly spreads from fecal matter of infected people to drinking water and even salad vegetables. Typhoid fever is common in all seasons in Nepal, and remained at the top during monsoon season [6]. Typhoid is reported as a seasonal disease in Western Nepal, with a high rate of cases in summer monsoon (July and August) and few cases in winter months (December and January) [8]. A review paper based on community water improvement in developing countries argued that typhoid is also seemed to be sensitive to different environmental and community-based avoidable and unavoidable factors [9].

Limited studies [10, 11] on typhoid fever are available in Nepal, being concentrated only in Kathmandu and Eastern Nepal. Conversely, the Department of Health Services (DoHS) reported that the typhoid cases have been prevailing in high rates at outside Kathmandu since a decade [8]. The Nepal burden of disease 2017 report also concluded that typhoid is prevailing at high rates across the western part of the country [6]. At the meantime, Western Nepal is considered as highly sensitive to

TAKE-HOME MESSAGE

Adaptation plan for extreme winter temperature, replantation of medicinal plants and clean river water seem urgent actions to control typhoid prevalence in Western Nepal.

Competing interests - none declared.

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environmental changes and associated with a high prevalence of this disease [12, 13]. After the review of the available studies; it is inferred that most of the studies on typhoid are urban-based, limited studies focused on eastern Nepal, and no study is found documenting the typhoid prevalence in Western Nepal.
Therefore, this research aims to explore the environmental and household characteristics associated with the typhoid prevalence in Western Nepal documenting the typhoid-related information, linking with environmental and community characteristics in the region. The findings of this study have policy implications as they provide the baseline information for health and environment policymakers in Nepal for the prevention and control of typhoid fever in Western Nepal.

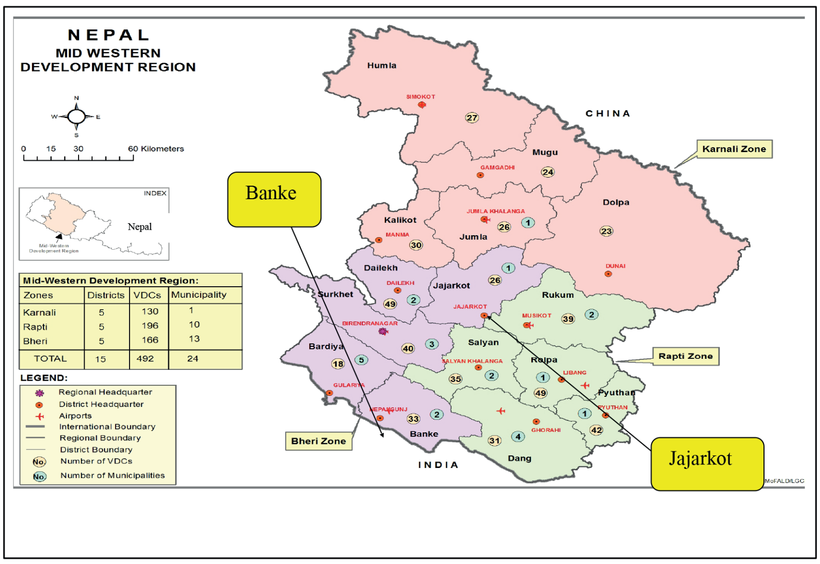
METHODS

Study design and procedure

A sampling frame of households at risk and a semi-structured questionnaire were used for a cross-sectional household survey data during 2018. The major technique for household interviews among 420 sample households was a systematic simple random sampling method with a random start. In-depth interviews of the head of sample households were carried out for data collection. The survey data was supplemented through focus group discussions with health professionals and community residents using questionnaires containing both qualitative and quantitative aspects. The datasets were compiled in the SPSS and transferred into the STATA for the probit regression analysis.

Study participants and sampling

This study involved 420 household heads of two districts (Jajarkot and Banke) of Western Nepal (Figure 1) as survey sites, which join the higher mountains to the Terai region and have high disease prevalence. To address the disease situation at the country level, the two districts with the highest incidence of the disease and that are highly sensitive to environmental changes were purposively chosen for the study [14].
A rapid assessment study was followed by the final survey across the selected districts. Veri municipality and Junichande rural municipality in Jajarkot, and Nepalganj municipality, and Janaki rural municipality in Banke district were selected based on information provided by the respective district Public Health Offices considering a high incidence of disease and population heterogeneity. Next, a



Note: VDC = Village Development Committee

Figure 1. Map of the study area (Source: MoFAGA, 2016) [15].

systematic sampling with a random start was applied for the selection of the sample households. The first household was selected randomly and every sixth dwelling was selected subsequently in each municipality. The average distance between consecutive sampling units was roughly 500 m. Detail information of the study setting was mentioned in previous publication [14].

Study instrument and measures

A semi-structured questionnaire was used to collect the cross-sectional data from 420 households. Public health professionals were employed in data collection. With reference to the survey database, some of the relevant variables were chosen from a big list of variables based on the literature. Variables of interest that are hypothesized to affect typhoid prevalence were described with their hypothesized or expected sign [increasing (+ve) or decreasing (-ve)] of probability of typhoid prevalence (Table 1). Multi-collinearity among the hypothesized variables was checked through coefficients (< 0.5) of correlation matrix [16]. The prevalence was acquired by definition as the number of typhoid patients at home divided by family size. Here, typhoid occurrence (yes, no) was the dependent variable. So, probit model seems best fit to find environmental predictors on typhoid prevalence, controlling household characteristics (covariates). The covariates are the dummy variables. Modeling for a binary dependent variable, let p_y be the probability of changing typhoid prevalence *(T)* due to the possible change in explanatory (exposure) variables *y*, and taking the value of 1 with given probability of changing disease prevalence. The probability of increasing or decreasing the typhoid prevalence can be expressed as,

$$p_y = p(T|_{Y=y}) = \frac{1}{1+e^{(-a+by)}} \quad \text{---------- (3)}$$

To express in further simplified form, log odds of typhoid prevalence linearly changes with change in *y*, then the probability of changes in diseases occurrence can be shown in logistic regression equation as,

$$Log\left(\frac{p_y}{1-p_y}\right) = Log(oddsforp(T|_{Y=y}) = a + by \quad \text{--------- (4)}$$

Where, $p(T|_{Y=y}) = p_y$ = Risk for typhoid prevalence

The final logistic regression equation for this study then takes the form,

$$T_{it} = \beta_0 + \beta_j E_{ijt} + \beta_k Y_{ikt} + \beta_l B_{ilt} + e_{it} \quad \text{------------- (5)}$$

Where, T_{it}: Typhoid prevalence of i^th^ household at time interval t

b_0 : Constant coefficient

b_j : Vector of coefficients for environmental factors

E_{ijt} : Vector of environmental variables at time t

Table 1. Description of hypothesized variables affecting typhoid.

Variables name	Description	Hypothesized sign
E02Winter_Temp	Winter temperatures	+ve [17]
F01Hea_Ra	Heavy rainfalls	+ve [18]
J02HotAir	Exposure to heat waves	+ve
J03Wat_inRiver	Polluted river water	+ve [1,19]
K01BD_SH	Decreased shrub cover	Indeterminate
A09Age	Age of respondent	-ve [20]
I33Awa_Prog	No participation in education and awareness programs	+ve
C06Vetenary_Dis	Distance to veterinary center (Km)	-ve
L01Hand_wash	Hand washing with water and soap	-ve [18]
L03Meal_pref	More frequent consumption of lightly cooked meals	+ve

b_k : Vector of coefficients of household socioeconomic characteristics

Y_{ikt} : Vectors of household socioeconomic characteristics at time t

b_l : Vector of coefficients of household behavioral variables

B_{ilt} : Vector of household behavioral variables at time t

e_{it} : Random error term

Ethical aspects

Written informed consent was acquired from the study participants before the data collection. Voluntariness to participate in the study was ensured. This study obtained ethical approval from the Ethical Review Board of Nepal Health Research Council (*Ref. No. 1887*).

Data analysis

The data was first entered into SPSS for some descriptive analysis and transferred to STATA for further analysis. Some descriptive analyses of categorical variables were presented in numbers and percentages. And the cross-tabulation results and regression analysis were identified using STATA software.

RESULTS

Descriptive results

The demographic and socioeconomic characteristics of study participants have been already documented in a paper devoted only on descriptive analysis of the same dataset [14]. To be more specific to typhoid prevalence, out of the total of households surveyed (*n* = 420), 46% of participants were affected by typhoid rampant in 2018. Of those who were affected by this disease, 58% were males, mainly employed in agriculture. The average family size was quite higher (*n* = 6.4) in the project areas than the national average (*n* = 4.4) [21], and typhoid fever seemed to be more prevalent among larger family size than smaller (Figure 2).

Occurrence of typhoid among the households using clean and unclean cooking fuel followed the same pattern. However, low education level was observed among the households facing typhoid prevalence (Figure 3). Furthermore, typhoid-affected households using wood as cooking fuel had relatively much lower level of education, compared to the households using clean fuel.

Typhoid-affected families using spring-well as the major water source, as well as drinking water source of stone-waterfall, had a high average income level compared to non-affected households. This result showed that typhoid cases are more affected by the sources of drinking water than by the household income level and its sources.

Regression results

Probit regression results in Table 2 showed that lower winter temperature and hot air movement, as well as decreased levels of water amount in the river and shrubs in the study area are potentially significant environmental risk factors of typhoid rampant in Western Nepal. Similarly, extremely cold winter in this study seemed more likely to increase the probability of typhoid fever compared to warmer winter. More precisely, extreme cold winter temperatures had adjusted OR (aOR) as 2.22 [95% Confidential Interval (95% CI) 1.15 to 4.28)] of typhoid fever compared to those who experienced normal winter temperatures. The odds of typhoid fever among those less exposed to heat waves was 0.36 (95% CI 0.16 to 0.81) compared to households that were more exposed, meaning that less exposure to heat waves is supportive to control the typhoid prevalence in the community.

Communities dependent on river and rivulets for drinking water could be exposed to polluted water. In our study, polluted river water was more likely to increase the likelihood of getting into typhoid fever, because some families are used to drink river water without cleaning it (aOR = 2.11, 95% CI 1.18 to 3.78). In this study, a result innovatively revealed that decreased shrub level was more likely to increase typhoid fever with the odds of 2.32 (95% CI 1.32 to 4.06). Furthermore, this stu-

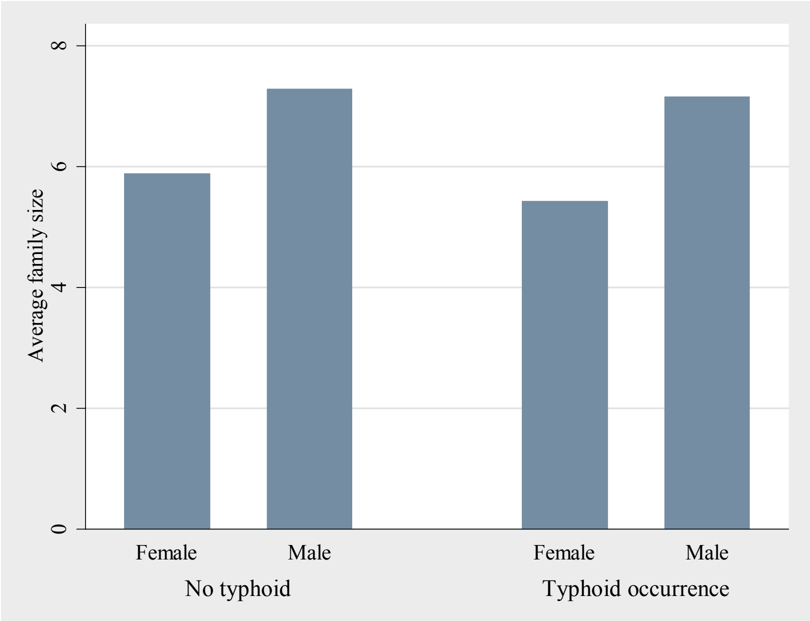


Figure 2. Typhoid occurrence by sex and family size.

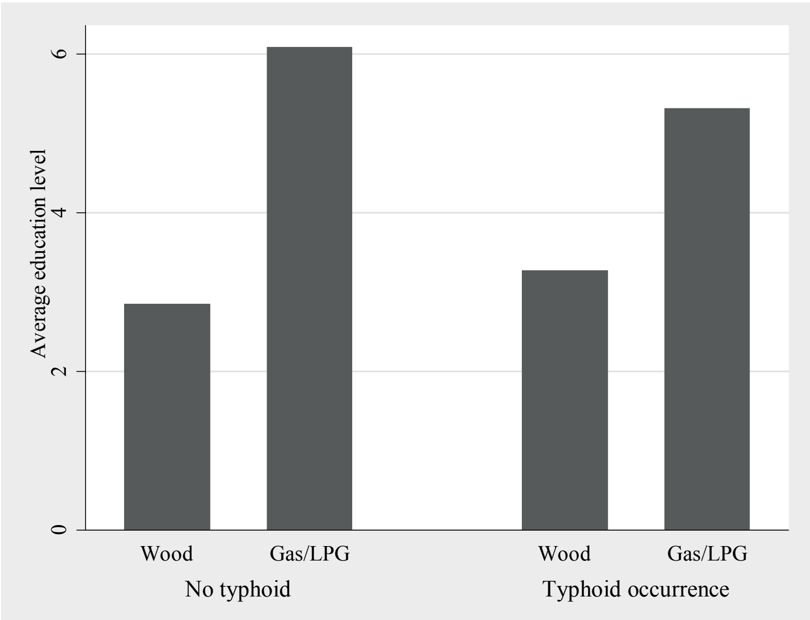


Figure 3. Typhoid occurrence by use of cooking fuel.

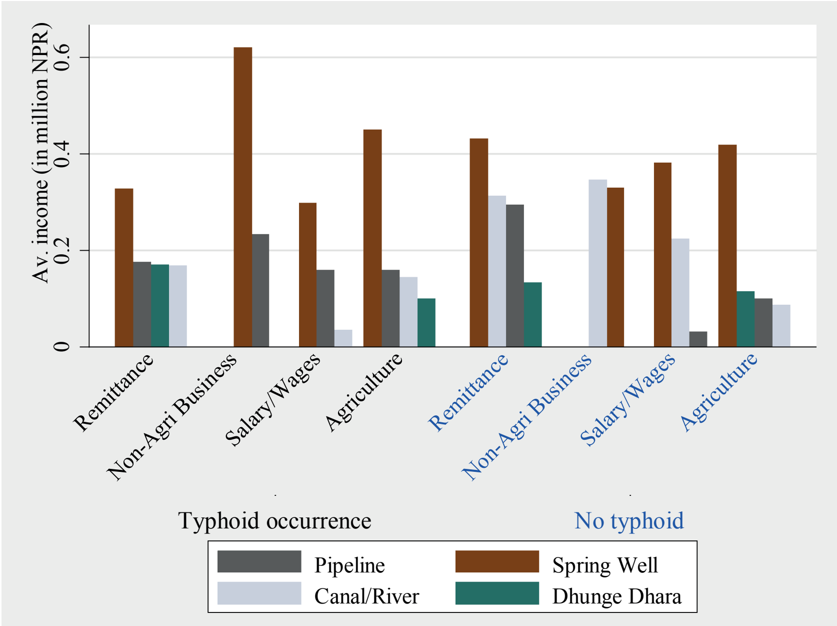


Figure 4. Typhoid prevalence by source of drinking water at given average household income level and its sources.

Table 2. Probit regression result for typhoid disease.

Study variables	Coefficients (Standard Error)	Adjusted OR (95% CI)
Extreme winter temperatures	0.479** (0.200)	2.22 (1.15-4.28)
Heavy rainfalls	0.330 (0.200)	1.71 (0.90-3.24)
Low exposure to heat waves	-0.611** (0.243)	0.36 (0.16-0.81)
Polluted river water	0.455*** (0.178)	2.11 (1.18-3.78)
Decreased shrub cover	0.508*** (0.171)	2.32 (1.32-4.06)
Age of household heads	-0.017*** (0.006)	0.97 (0.94-0.99)
No participation in education and awareness programs	0.754*** (0.245)	3.59 (1.54-8.34)
Distance to veterinary center (Km)	0.0342* (0.0187)	1.05 (0.99-1.12)
Hand washing with water and soap	-0.333** (0.166)	0.75 (0.10-0.95)
More frequent consumption of lightly cooked meals	-0.223 (0.149)	0.69 (0.42-1.12)
	R^2 = 0.12	

Note: *** = P <0.001, ** = P <0.05, * = P <0.01, Dependent variable: Typhoid occurrence (Yes=1, No=0). Number in the parenthesis = Standard Error (Source: Field Survey, 2018) [14] dy also showed that ageing is less likely to have the chance of typhoid fever (aOR = 0.97; 95% CI 0.94 to 0.99). No participation of the household head in health education and awareness programs was associated with odds of 3.59 (95% CI 1.54 to 8.34) of getting typhoid fever. Households using soap and water for washing hands before and after meal were less likely to have the typhoid fever (aOR = 0.75; 95% CI 0.10 to 0.95), compared to those who washed hands with only water. More frequent consumption of lightly cooked meal, distance to veterinary center (Km), and heavy rainfalls in the community were with positive coefficient but statistically insignificant to explain the typhoid fever prevalence.

DISCUSSION

This empirical research demonstrates that several environmental and household characteristics are associated with quantifiable odds of having typhoid fever in Western Nepal. Our findings are useful in estimation of typhoid fever disease burden in low- and middle-income countries like Nepal [22], which demarcates high-risk population who would benefit maximum from typhoid interventions such as reducing river water pollution, adopting appropriate adaptation strategies for inextricable environmental changes such as temperature and heat waves caused by climate change, and implementing programs for sanitation and vaccination. Other significant typhoid risk reduction factors are observed concerning better socioeconomic status, improved hygiene and sanitary practices and typhoid fever education and awareness programs. These factors should be quantified in future analyses and should be included in future typhoid disease burden estimates.
Consistently with our findings, a study by Saad et al [11] showed that extreme winter temperatures aggravate typhoid prevalence. Thindwa et al [23] argued that the relative-risk function of temperature for typhoid is at higher risk at both lower and higher temperatures, possibly reflecting the known patterns of short and long cycle typhoid transmission. The argument by Thindwa et al [23] is consistent with our study findings as the heat waves encourage spreading the typhoid fever at the community level. Quality status of water bodies also significantly changes the pattern of typhoid fever. Polluted water in rivers and lakes might have direct impact on community health, especially on waterborne diseases. Our study observed that households consuming unclean river water without any treatment double the risk of typhoid fever, compared to households using clean water sources. This finding is consistent with Indian [24] and Indonesian [25] researches. Beach et al. reported that clean water technologies can reduce typhoid in children by increasing their level of educational attainment and by increasing future earning after grown up by one to nine percent [26].
Forests and shrubs in rural areas of Nepal are also hubs of medicinal plants which are largely medicinal and aromatic shrubs and herbs in their plant categories. Local Vaidhya (practitioners of herbal medicine by using indigenous tradition) use different medicinal plants for treatment of diseases like typhoid [27]. At the meantime, decline of shrubs including the medicinal plants was observed to increase the prevalence of typhoid, which is a critical issue to preserve such valuable plants and ecology. Decreasing medicinal plants at increasing rate has direct impact on rural disease prevalence, as rural community still normally uses locally available medicinal plants for several diseases [28]. Due to loss of medicinal plants in their locality and poor knowledge of application of such plants to treat typhoid fever among new generations, the people face critical health situations and run to visit health facilities which are far away from their settlements and less equipped than required for such situation.
Consistently with a study conducted in India [20], this research showed that ageing is associated with decreased chances of having typhoid prevalence in the community. Participation of household heads in awareness programs is also associated with decrease in typhoid fever, but this finding is unexpectedly reverse with the result of a study conducted in Bangladesh [1]. Much care of sanitation

measures including hand wash with soap before and after the meal was also significantly effective to reduce typhoid fever. This finding is consistent with studies by Vollaard [25], Saad et al [11] and Thindwa et al [23], suggesting that maintenance of personal hygiene, better-quality sanitation and cleanliness of water are substantial contributors to control typhoid occurrence.

Our research is not without limitations. Indeed, this study has not accounted for some individual and structural factors such as self-reported typhoid fever vaccine status, type of home toilet, type of sewage system, which were analyzed in previous studies, and clinical measures such as microbiological examination for water contamination which should be considered in future disease burden studies [30, 31]. However, the results of this study can provide policymakers and researchers with baseline information or guidelines for empirical evidence of typhoid risk factors across Western Nepal, especially linking with environmental conditions including climate change [32, 33].

CONCLUSION

This research delineated an association between environmental and household characteristics and typhoid fever occurrence in Western Nepal. Extreme winter temperatures, river water pollution, decreased shrub cover including medicinal plants and increased heat waves were found to be major environmental causative agents, which are likely to increase the typhoid prevalence in Western part of Nepal. For this reason, an appropriate adaptation packages against the inextricable environmental factors at the community level and replantation or conservation of medicinal and other shrubs surrounding the community seem urgent. Additionally, participation of community people in health awareness programs, awareness on sanitization of hands with water and soap before the meal and personal hygiene maintenance seem to be urgent measures to reduce the typhoid prevalence in Western Nepal. In conclusion, this research suggests some policies and programs for addressing the present environmental challenges for the control of typhoid fever in Western Nepal.

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