Risk Factors for Typhoid Fever Occurrence and Recurrence in Gombe Metropolis, Gombe State, Nigeria

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Abstract

Typhoid is a life-threatening disease that has remained endemic in parts of Africa and Asia where its burden is elevated by the inefficiency of control efforts which have been hampered by lack of epidemiological data, among others. In Nigeria, such data is absent in most of the States like Gombe where the disease has been rife for a long time, hence, to bridge that knowledge gap, this study was set up to determine the host-associated risk factors for typhoid occurrence and recurrence in Gombe. A questionnaire that was designed and validated for this location was used to obtain data from 663 respondents using simple random sampling and analyzed using the Chi-square test for association and binomial logistic regression to obtain risk factors for typhoid occurrence and recurrence, respectively. The study revealed that occurrences were statistically significantly associated with the variables for vaccination ($\chi^2 = 39.729$, $p < 0.01$), having houseboy/girl ($\chi^2 = 16.909$, $p < 0.01$), typhoid patient at home ($\chi^2 = 13.393$, $p < 0.01$), hand washing before handling food ($\chi^2 = 22.856$, $p < 0.01$), consuming iced/frozen items ($\chi^2 = 16.805$, $p < 0.01$), boiling drinking water ($\chi^2 = 49.633$, $p < 0.01$), and eating commercially available foods/drinks ($\chi^2 = 27.864$, $p < 0.01$), while recurrences were statistically significantly predicted by ‘not sure of been vaccinated’ (OR = 2.962, CI = 1.290 to 6.802, $p < 0.01$), ‘not having another typhoid patient at home’ (OR = 1.799, CI = 0.998 to 3.244, $p < 0.01$), and ‘drinking unboiled water sometimes’ (OR = 2.130, CI = 1.023 to 4.434, $p < 0.01$). It is believed that these findings will guide efforts by the Government for health interventions against typhoid in the study area, thus improving the quality of life for the population.

Keywords: Risk factors, Typhoid, Occurrence, Recurrence, Gombe, Nigeria

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1. Introduction

Typhoid fever is a human-specific disease that manifests following contagion by the Gram-negative *Salmonella typhi* bacterium, which is commonly contracted through consumption of eatable or drinkable items contaminated with feces or urine of *S. typhi*-shedding carriers that are usually non-symptomatic. The symptoms of typhoid fever sometimes referred to as enteric fever incorporate abdominal pain, dogged fever with accompanying headache, nausea, paradoxical bradycardia, atrophy, lethargy, loss of appetite, and rose spots, which can be categorized from less complex high-grade fever to more complex and stern disease which paves the way to hemorrhage, peritonitis, encephalopathy, and intestinal perforations which can be fatal without timely medical interventions [1].

Yearly occurrences of this disease and the part it contributes towards elevating human mortality and morbidity pose great concerns based on reports of over 25 million cases of this infection annually as published by the World Health Organization [2]. Many health information gaps exist in many states of developing nations concerning the health problems resulting from typhoid fever, and also, information regarding typhoid in specific communities is scanty, confined to poorly developed areas, and appropriately documented in only a few cases, and considering the real possibility for arrival of vaccines with higher efficiency, more priority should be delegated to identifying risk factors of typhoid fever based on geographical locations so that the right kind of immunization schedules can be designed and implemented [3].
Vaccines against typhoid fever have remained accessible to control and prevent the disease since the year 1896; however, due to this problem of insufficient information regarding the burden of the disease, their routine use as tools for efficient prevention of typhoid in endemic locations has been hindered [4]. This absence of accurate information has also made conclusions regarding priorities and allocation of resources problematic and is thought to negatively affect ventures into control and prevention of typhoid disease [5]. By the year 2018, the world health organization (WHO) had detailed that haste is required in generating epidemiological data that will improve immunization schedules and their efficiency against typhoid and for influencing policies on the vaccinations against the continued occurrence of the disease [6].

In Gombe State, Nigeria, there are no adequate scientific publications about typhoid risk factors, this is believed to have directed the sustained existence of the infection and seeming failure of any control policy that might be in existence since the inhabitants most at risk cannot be ascertained, and as such suitable targeted health interventions and the form and scale of such interventions cannot be efficiently determined.

2. Materials and Methods

2.1. Study Design

The study was an observational cross-sectional study that involved only patients with laboratory-confirmed typhoid fever in the study area [7]. Nonetheless, the outcome variable was designed to also collect information regarding previous laboratory-confirmed occurrences of typhoid among the respondents.
2.2. Study Location and Duration

The “State Specialist Hospital Gombe” was the location chosen for this research, because it is commonly utilized by a considerable portion of the population that live in the metropolis, it is straightforwardly reachable, and has the relatively good diagnostic equipment and processes compared to the other State-owned health facilities. The data for this study were collected from 9th August 2019 to 30th November 2019.

2.3. Data Source

A questionnaire was designed, validated, and used in a self-administered manner (unless otherwise requested by respondent) to obtain exposure and outcome information from consenting patients in the study area. The data that was used for this study were recovered from only completely and correctly filled questionnaires. These data were then defined into fitting types of categorical or continuous variables before analyses.

2.4. Sample Size Determination and Sample Collection

The sample size for this study was determined to be 663 at a 99% confidence limit and 5% acceptable margin of error, using the Statcalc in Epi Info v 7.2.2.6 software of Centres for Disease Control and Prevention [8]. The 99% confidence limit was chosen to have enough statistical power to correctly reject the null hypothesis without magnifying recognition of variances in the outcome which would lead to statistically significant results that are not clinically significant [9]. A simple random sampling method (Figure 1) was used in issuing out and collecting questionnaires from respondents with laboratory-confirmed typhoid fever in the study area [10].
2.5. Data Analysis

The data analysis methods used were chosen based on the data nature and distribution, the associations been investigated between the variables, and the assumptions of the statistical tests [11].

**Chi-square Test of Association**

A chi-square test of association ($\chi^2$) at significance level $p = 0.01$ was used to determine if the host-associated risk variables were significantly associated with typhoid fever's overall occurrence in the study area. Before conducting the chi-square test, its
assumptions were checked. These assumptions include mutual exclusiveness of variable categories, study groups' independence, variable sufficiency, and definition [12]. This analysis was done using SPSS v26 for windows [13].

**Logistic regression**

Binomial logistic regression was carried out (at $p = 0.01$) on the risk variables significantly associated with overall typhoid occurrence to determine which of the categories of these variables were significant predictors of typhoid recurrence. Assumptions for logistic regression, which include; dependent variable ought to be quantified on a dichotomous scale, multiple and independent categorical variables, independence of observations, mutually exclusive and exhaustive categories in the dependent variable, were checked before executing the test [14]. This analysis was done using SPSS v26 for windows [13].

3. **Results**

3.1. **Characteristics of Questionnaire Respondents**

The characteristics of the respondents that provided information that was used for determining the host-associated risk factors are shown in the figures below. These include age (Figure 2), gender (Figure 3), occupation (Figure 4), and marital status (Figure 5).
Figure 2. Questionnaire Respondents’ Age Groups

Figure 3. Questionnaire Respondents’ Gender

(Key: young = 9 to 17, young_adult = 18 to 35, adult = 36 to 55, old_adult = 56 to 65, old = 66 to 85, very_old = 86 to 100)
Figure 4. Questionnaire Respondents’ Occupations

Figure 5. Questionnaire Respondents’ Marital Status
3.2. Chi-Square Test of Association Between Risk Variables and Typhoid

The results of the chi-square test for association between the predictor variables and the typhoid outcome (Table 1) revealed that typhoid vaccination, having house boy/girl, having another typhoid patient in the home, handwashing with soap before handling food, consuming iced/frozen items, boiling water before drinking, and eating commercial foods/drinks, were statistically significantly associated with the typhoid occurrence variable. These results are shown with more details in the following table, along with the values for the variables that were not statistically significantly associated with the typhoid occurrence variable.

Table 1. Values from the Chi-square Test for Association

<table>
<thead>
<tr>
<th>Predictor variables</th>
<th>Chi-square</th>
<th>df</th>
<th>Sample size</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typhoid vaccination</td>
<td>39.729</td>
<td>4</td>
<td>663</td>
<td><em>p &lt; 0.010</em></td>
</tr>
<tr>
<td>Having house boy or girl</td>
<td>16.909</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.002</em></td>
</tr>
<tr>
<td>Other typhoid case at home</td>
<td>13.393</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.010</em></td>
</tr>
<tr>
<td>Handwashing with soap before handling food</td>
<td>22.856</td>
<td>4</td>
<td>663</td>
<td><em>p &lt; 0.010</em></td>
</tr>
<tr>
<td>Consuming iced/frozen items</td>
<td>16.805</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.002</em></td>
</tr>
<tr>
<td>Boiling water before drinking</td>
<td>49.633</td>
<td>4</td>
<td>663</td>
<td><em>p &lt; 0.010</em></td>
</tr>
<tr>
<td>Eating commercial foods/drinks</td>
<td>27.864</td>
<td>4</td>
<td>663</td>
<td><em>p &lt; 0.010</em></td>
</tr>
<tr>
<td>Typhoid carrier in home</td>
<td>11.986</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.017</em></td>
</tr>
<tr>
<td>Tiles on kitchen floor</td>
<td>8.666</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.070</em></td>
</tr>
<tr>
<td>Type of kitchen</td>
<td>9.178</td>
<td>6</td>
<td>663</td>
<td><em>p = 0.164</em></td>
</tr>
<tr>
<td>Toilets/faeces near water source</td>
<td>2.303</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.680</em></td>
</tr>
<tr>
<td>Hands-on farming</td>
<td>2.769</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.597</em></td>
</tr>
<tr>
<td>Level of education</td>
<td>18.239</td>
<td>8</td>
<td>663</td>
<td><em>p = 0.020</em></td>
</tr>
<tr>
<td>Other treatment for drinking water</td>
<td>0.086</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.999</em></td>
</tr>
<tr>
<td>Sharing eating utensils at the same time</td>
<td>9.463</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.051</em></td>
</tr>
<tr>
<td>Attended any mass gathering within the last two weeks</td>
<td>10.801</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.029</em></td>
</tr>
<tr>
<td>Collecting any food item from river or stream near main road</td>
<td>8.771</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.067</em></td>
</tr>
<tr>
<td>Using public toilets</td>
<td>9.520</td>
<td>4</td>
<td>663</td>
<td><em>p = 0.049</em></td>
</tr>
</tbody>
</table>
3.3. Logistic Regression for Predicting Typhoid Recurrence Risk Factors

The outcome of the logistic regression analysis revealed that the model had $\chi^2$ (df = 14, N = 663) = 70.238 with $p < .010$, Nagelkerke R$^2 = .147$, Hosmer and Lemeshow $\chi^2$ (df = 8, N = 663) = 3.843 with $p > .010$, block 0 classification table with 73.50% correctness, and block 1 classification table with 75.70% correctness. The values for the categories of the variables in the equation of the logistic regression (Table 2) revealed that vaccination against typhoid (1: not sure), having another typhoid patient at home (2: no), and boiling water before drinking (1: sometimes), were statistically significant predictors of typhoid recurrence.
Table 2. Values for the Categories in the Logistic Regression Equation

<table>
<thead>
<tr>
<th>Variable category</th>
<th>B</th>
<th>SE</th>
<th>Wald $\chi^2$</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
<th>99% CI for Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccination against typhoid (1: not sure)</td>
<td>1.086</td>
<td>0.323</td>
<td>11.317</td>
<td>1</td>
<td>0.001</td>
<td>2.962</td>
<td>1.290 - 6.802</td>
</tr>
<tr>
<td>Vaccination against (2: no)</td>
<td>0.002</td>
<td>0.225</td>
<td>0.000</td>
<td>1</td>
<td>0.992</td>
<td>1.002</td>
<td>0.562 - 1.788</td>
</tr>
<tr>
<td>Having houseboy/girl (1: sometimes)</td>
<td>0.311</td>
<td>0.219</td>
<td>2.008</td>
<td>1</td>
<td>0.157</td>
<td>1.365</td>
<td>0.775 - 2.402</td>
</tr>
<tr>
<td>Having houseboy/girl (2: no)</td>
<td>0.418</td>
<td>0.284</td>
<td>2.159</td>
<td>1</td>
<td>0.142</td>
<td>1.519</td>
<td>0.730 - 3.160</td>
</tr>
<tr>
<td>Having another typhoid patient at home (1: not sure)</td>
<td>0.639</td>
<td>0.253</td>
<td>6.393</td>
<td>1</td>
<td>0.011</td>
<td>1.896</td>
<td>0.988 - 3.636</td>
</tr>
<tr>
<td>Having another typhoid patient at home (2: no)</td>
<td>0.587</td>
<td>0.229</td>
<td>6.582</td>
<td>1</td>
<td>0.010</td>
<td>1.799</td>
<td>0.998 - 3.244</td>
</tr>
<tr>
<td>Washing hands with soap before handling food (1: sometimes)</td>
<td>0.136</td>
<td>0.306</td>
<td>0.198</td>
<td>1</td>
<td>0.657</td>
<td>1.146</td>
<td>0.521 - 2.516</td>
</tr>
<tr>
<td>Washing hands with soap before handling food (2: no)</td>
<td>-0.221</td>
<td>0.272</td>
<td>0.656</td>
<td>1</td>
<td>0.418</td>
<td>0.802</td>
<td>0.398 - 1.617</td>
</tr>
<tr>
<td>Consuming iced/frozen products (1: sometimes)</td>
<td>0.001</td>
<td>0.238</td>
<td>0.000</td>
<td>1</td>
<td>0.998</td>
<td>1.001</td>
<td>0.542 - 1.846</td>
</tr>
<tr>
<td>Consuming iced/frozen products (2: no)</td>
<td>-0.153</td>
<td>0.255</td>
<td>0.358</td>
<td>1</td>
<td>0.550</td>
<td>0.859</td>
<td>0.445 - 1.656</td>
</tr>
<tr>
<td>Boiling water before drinking (1: sometimes)</td>
<td>0.756</td>
<td>0.285</td>
<td>7.058</td>
<td>1</td>
<td>0.008</td>
<td>2.130</td>
<td>1.023 - 4.434</td>
</tr>
<tr>
<td>Boiling water before drinking (2: no)</td>
<td>0.058</td>
<td>0.268</td>
<td>0.046</td>
<td>1</td>
<td>0.830</td>
<td>1.059</td>
<td>0.531 - 2.113</td>
</tr>
<tr>
<td>Eating commercial foods/drinks (1: sometimes)</td>
<td>0.513</td>
<td>0.321</td>
<td>2.557</td>
<td>1</td>
<td>0.110</td>
<td>1.671</td>
<td>0.731 - 3.821</td>
</tr>
<tr>
<td>Eating commercial foods/drinks (2: no)</td>
<td>-0.115</td>
<td>0.258</td>
<td>0.198</td>
<td>1</td>
<td>0.656</td>
<td>0.892</td>
<td>0.459 - 1.731</td>
</tr>
</tbody>
</table>
4. Discussion

4.1. Risk Factors for Typhoid Occurrence

In this study, vaccination as a variable was statistically significantly associated with typhoid fever. This is believed to be because of misconceptions and existing beliefs among the local population in the study area about vaccines being tools of a conspiracy designed to depopulate the community, make women infertile, or predispose children to life-threatening ailments that will manifest in adulthood. Such misconceptions and beliefs are believed to have led to hesitation and even vaccine refusal, which has developed into the main barriers against immunization schedules in many states of Nigeria, including Gombe [15].

The relationship between the occurrence of typhoid and having a house boy or house girl (house help) is believed to stem from the fact that such individuals are most likely healthy carriers of the typhoid pathogen and, as such, are actively contaminating food during preparation [16] and serving since it is customary that house helps prepare and handle food among many households in the study area.

The existence of another typhoid patient at home is believed to present a risk for occurrence of typhoid due to direct or indirect interaction with the patient, especially by sharing toilets and food items directly, which leads to touching surfaces and consuming items contaminated by the patient [17], and subsequent infection by the pathogen which has a relatively low infectious dose [18].

Handwashing with soap or detergents before handling food is statistically significantly associated with typhoid fever in this study as a variable. This is believed to be due to
improper or total absence of handwashing in the study area due to lack of adequate water supply, which has been shown to act as a barrier to adequate and proper washing of hands and also because the human hands and fingers play the most important roles in the fecal-oral transmission of the typhoid pathogen [19].

The consumption of iced or frozen items is statistically significantly associated with typhoid fever in this study. This is believed to be due to the ability of the typhoid pathogen to remain viable even in frozen environments [20], which allows the bacteria to survive in local frozen beverages and ice blocks commonly consumed during hot weather in the study area and which must have been produced using unhygienic sources of water [21].

The lack of boiling water before drinking is statistically significantly associated with typhoid fever in this study. This is believed to be due to lack of stable supply of hygienic water in the study area [22] which has led people to utilize locally constructed wells, improperly maintained boreholes, commercially hawked jerrycan water, water trucks, sachet water, and other unhygienic water sources for drinking and other daily activities, just like in some locations of Pakistan [23] where typhoid occurrences were all linked to utilization of unhygienic water sources.

The consumption of commercially available foods and drinks is statistically significantly associated with typhoid fever in this study. This is believed to be due to large numbers of workers and students who patronize food vendors that are mostly located in unsanitary environments, practice unhygienic cleaning of plates/utensils and unhygienic food preparation/handling/serving processes, just like in nearby Bauchi where such issues were implicated as sources of food-borne infections [24]. Such
activities often lead to contamination of food items that have been reported to have a higher capability of harboring larger doses of the typhoid pathogen [25], which makes contaminated food a very important typhoid risk factor. Also, fresh fruits and vegetables are commonly used as part of food in the study area, where they serve as sources of typhoid transmission if they are sourced from farms that utilize untreated irrigation water and then consumed without proper hygienic processing [26].

4.2. Risk Factors for Typhoid Recurrence

The logistic regression model was statistically significant; it explained 14.7% of the typhoid recurrence variance and correctly classified 75.7% of the cases [27,28].

Individuals who are not sure of being vaccinated against typhoid within the last two years are more likely to have typhoid recurrence than individuals who are sure of being vaccinated. These inferences are based on the results of the logistic regression, which revealed that category one (not sure) under typhoid vaccination variable had $p < .01$ and Exp(B) value of 2.962 with 99% CI values of 1.290 to 6.802. This means that not sure of being vaccinated statistically significantly elevated the odds of typhoid recurrence by 2.962 times but could vary between 1.290 and 6.802 times. These interpretations were surmised based on the works of Hinton and Kleinbaum & Klein [27,28] and agree with the work of Bilcke et al. [29] who described how routine immunization programs against typhoid had the potential to result in a 30% decline in typhoid occurrences over 120 months.
Individuals who do not have another (previous) typhoid patient at home are more likely to have a recurrence of typhoid than individuals who have had another typhoid patient at home. This is based on the logistic regression outcome for the ‘no’ category under having another typhoid patient at home variable, which had $p < .01$ and an Exp(B) value of 1.799 with 99% CI values 0.998 to 3.244. These implied that individuals who do not have another (previous) typhoid patient at home have 1.799 times more odds of typhoid recurrence, but this value could range between 0.998 to 3.244 times. These interpretations are based on descriptions of logistic regression deduced from the works of Hinton and Kleinbaum & Klein [27,28]. This finding is believed to be possible because having another typhoid patient at home creates an avenue for other members of the home to gain more knowledge about typhoid, how it is transmitted, and how to avoid infection by the pathogen [30].

Individuals who boil water sometimes before drinking are more likely to have typhoid recurrence than individuals who always boil water before drinking. This is based on the logistic regression outcome for the ‘sometimes’ category under ‘boiling water before drinking’ variable in this study which had $p < .01$ and Exp(B) value of 2.130 with 99% CI values of 1.023 to 4.434, which mean that the odds of having typhoid recurrence were 2.130 times higher for individuals that do not boil water always before drinking, and based on the CI values, these odds will range between 1.023 to 4.434 times. These interpretations are based on published descriptions of logistic regression by Hinton and Kleinbaum & Klein [27,28]. The situation portrayed by this finding is believed to be possible because the need to boil water before drinking usually arises from the perception of the quality of the water [31] hence it is believed that in the study area people who always obtain drinking water from hygienic sources like sealed bottle water do not boil such water before drinking, while people who obtain water from
sources with questionable hygiene usually boil such water before drinking, but may be unable to do so all the time due to lack of electricity or lack of patience due to high level of thirst at some moments which elevates their risk of consuming water contaminated with the typhoid pathogen.

5. Conclusion

Typhoid occurrences in Gombe metropolis are statistically significantly associated with lack of vaccination, having a house boy/girl, having another typhoid patient at home, lack of handwashing with soap before handling food, consuming iced/frozen items, not boiling water before drinking, and eating commercially available foods/drinks, while recurrences of the disease were statistically significantly predicted by uncertainty about vaccination status, not having another typhoid patient at home, and not boiling drinking water always. It is believed that this information will be invaluable to the identification of populations at risk and subsequent design and implementation of fitting prevention and control efforts.
Appendices

Appendix A: Ethical clearance for this study obtained from ministry of health headquarters Gombe State.
Appendix B: Respondents’ informed consent form

INFORMED CONSENT FORM

You are being requested to take part in a research project titled: _________________________________. This work is being done under the supervision of _________________________________ and is approved by _________________________________.

The investigator aims to acquire ________________________________ from this project. While taking part in this study, you will be asked to ________________________________ for some minutes of your time.

The nature of this research shall be explained by ________________________________, the expected benefits of your participation are ________________________________, the known risks of you taking part in this research are _________________________________.

The researcher will make all efforts to protect the confidentiality of the information and data that you offer. Any information collected in this study that can be identified with you will remain confidential and will not be given to anyone except with your signed permission.

If at any point in time you will like any additional information about this project, you can contact ________________________________ at _________________________________.

You have the right to refuse to take part in this study. If you do agree to take part, you have the right to change your mind at any time and end your participation.

The services you receive from ________________________________ hospital/clinic/laboratory will not be negatively affected if you refuse to participate or withdraw from this study.

Your signature below shows that you have given your informed consent to take part in the above-described research.

Your signature also indicates that:

1. You/Your Guardian have been given the opportunity to ask any and all questions on the described project and your participation and all your questions have been answered to your satisfaction.
2. You/Your Guardian have been allowed to read this document and you have been given a signed copy of it.
3. You and/or Your Guardian are at least 18 years of age.
4. You and/or Your Guardian are legally able to understand and provide consent.
5. To the best of your knowledge and belief, You/Your Guardian have no physical or mental health problems that can be negatively affected by your participation in the described project.

Signature of Participant or Participant’s representative ________________________________ Date

Signature of Witness ________________________________ Date

THANK YOU VERY MUCH
Ethics

The ethical approval for this research (ref. no.: MOH/ADM/S/658/VOL/II/122) was obtained from the Gombe State Ministry of Health headquarters. Guidelines concerning respondents’ informed consent, their privacy, confidentiality/anonymous collection/handling of data, and ethical conduct of research were adhered to.

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Declaration of Interests

None.

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References


