ADRRI JOURNAL OF MEDICAL AND BIOMEDICAL RESEARCH

*ADRRI JOURNAL (***www.adrri.org***)*

pISSN: 2026-6022 ***ISSN-L***: 2026-6022 VOL. 1, No.3(1), July, 2016

Negative Binomial Regression Model of Typhoid Fever Trajectory in Saboba District of Ghana.

Nborlen Mark Nte-Adik[1], Enock Mintah Ampaw[2], Seth Opoku Larbi[2], Kwame Asare Gyasi-Agyei[2], Samuel Lartey[3].

[1]Assemblies of God Hospital, Post Office Box 29, Saboba, Ghana. [1]Email: nteadik@gmail.com

[2]Koforidua Polytechnic, P. O. Box 981, Koforidua, Ghana. [2]Email: sendtoampaw@yahoo.com

[2]Email: lasetho@yahoo.com [2]Email:gaakus@yahoo.com

[3]Controller and Accountant General Department, Koforidua, Ghana
[3]Email: sammylart@yahoo.com

[2]**Correspondence**: Email: sendtoampaw@yahoo.com

Received: 22nd May, 2016 **Revised**: 26th July, 2016 **Published Online**: 31st July, 2016

URL: http://www.journals.adrri.org/ http://www.journals.adrri.com

[**To Cite this Article**: Nte-Adik, M. N., Ampaw, E. M., Larbi, S. O., Gyasi-Adjei, K. A., and Lartey, S.(2016). **Negative Binomial Regression Model of Typhoid Fever Trajectory in Saboba District of Ghana.** ADRRI Journal of Medical and Biomedical Research, Ghana: Vol. 1, No. 3 (1), Pp. 1-15, **ISSN**: 2343-6891, 31st July, 2016]

Abstract

Typhoid fever has always been a major health problem, and therefore, timely and accurate information about its occurrence rate is imperative. The main objective of the research was to model the prevalence of typhoid fever in Saboba district given the demographic age groupings, gender and time. Data on the incidence of typhoid fever in Saboba district (2009 - 2013) were obtained from the Saboba District Health Information Management database. Statistical Analysis System (SAS) was used to analyze the acquired data. Based on the model diagnostics, the Negative Binomial regression model was emerged as superior to the Poisson regression model. This is because it was able to accommodate the over-dispersion that existed in the dataset. The results from the Negative Binomial regression model indicated that, typhoid fever in Saboba District is independent of gender. With the demographic age grouping of typhoid patients, it was established that, the infectious rate of typhoid fever in Saboba District was comparatively mild or nonthreatening in young children and the aged. Young adults or the economically active age groups suffer more of typhoid infection in Saboba District. The Mann –Kendall test results showed downward trend of the prevalence of typhoid fever among the observed years. More cases of typhoid fever were recorded in the year 2009 followed by a sharp decrease until 2012. Between 2012 and 2013, the incidence of typhoid fever in the district assumed an upward trend.

Keywords: Typhoid Fever, Negative Binomial Regression Model, Poisson Model, Mann-Kendall Trend Test, Infection

INTRODUCTION

The prevalence of typhoid fever in developing countries remains high and it has been estimated at 540, cases per 100,000, of the population per year. The disease is especially threatening in countries where large parts of the population lack effective sanitation and good hygiene. Typhoid fever has a long history. It has being in existence for over 2,000 years. Thomas Willis was the first to be credited with the description of typhoid fever in 1659. Carl (1880) discovered the bacillus of typhoid fever and William Wood Gerhard became the first to differentiate clearly between the typhus fever (continuous fever characterized by a high temperature and a skin rash) and the typhoid fever in 1837. Georges Widal (1896) described the Widal agglutination reaction of the blood.

The exact date of discovery of typhoid fever in Saboba district has not been established, but it is estimated to be in existence as a health challenge for over twelve years now.

Kursah (2009) conducted a research into "Water sources, infrastructure, space and the dynamics of environmental diseases in Saboba district". He reported that the prevalence of typhoid fever in Saboba district were 161 total cases in the year 2002, 287 total cases in 2003, 3,844, total cases in 2004, and 7,725 total cases in 2005. Jean Young (2004), who had no idea as to when typhoid fever became established in Saboba district, however, acknowledged the disease as a problem. She described the problem as particularly terrible because, in May-June, she could operate six (6) typhoid perforation cases weekly and that was considered quite bad vis-à-vis the district population at the time.

Objectives of the Study

i. To model the prevalence of typhoid fever in the Saboba district by using age groupings, gender and, time.
ii. To determine the rate of occurrence of typhoid fever in the Saboba district.
iii. To graphically describe the prevalence of typhoid fever in the Saboba district base on year, gender and, age from the period 2009 – 2013.

Research Questions

i. What is the best fit model of typhoid fever in the Saboba district?
ii. What is the rate of occurrence of typhoid fever in the Saboba district?
iii. What is the graphical description of typhoid fever in the Saboba district with regard to year, gender, and age from the period 2009-2013?

Justification of the Study

In Ghana, studies on Typhoid fever are scanty and aggregated across the country. Thus, to draw conclusions for all districts in Ghana, with heterogeneous economic endowments and health delivery challenges is not wholly convincing. In addition to the general lack of detailed district level studies on Typhoid fever in Ghana, literature on the empirical evidence on the prevalence of Typhoid fever in the Saboba district is non-existent.

In the study, gender-disaggregated distribution, trend and, age group distribution of Typhoid fever, which is endemic in the Saboba district, were emphasized and analyzed.
Hence, the study would serve as documentary information for the public health officers in the Saboba district to come out with educative programs within the district toward the eradication of the disease.

METHODOLOGY

Data Collection and Organization

The data used for this study were obtained as secondary data from online DHIMS2 database. The data consisted of both out-patients and in-patients morbidity of typhoid reported cases in the Saboba District within a period of January 2009 to December 2013. The online DHIMS2 database included patient's demographic age grouping, gender and period (daily, weekly, monthly, yearly, among others). For this study, the monthly typhoid data were extracted with respect to the demographic age groupings and gender of the typhoid patients in the district. The extracted data were organized in a manner that was consistent with the statistical software, SAS.

Mann-Kendall Trend Test

Mann-Kendall Trend Test is a non-parametric test that is used to establish whether the dependent variable (Y), in this case, the monthly counts of typhoid fever in the Saboba district, tends to increase or decrease with independent variable (X), i.e gender, time (years) and demographic age groupings of the typhoid clients. Statistically, it is a test that is used to determine whether the stochastic process from which the data arise has changed over time. Following Salmi et al. (2002), the Mann-Kendall test is applicable in cases when the data values X_i of a time series can be assumed to obey the model:

$$X_i = f(t_i) + \varepsilon_i \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where the observations X_i are randomly ordered in time. The expression $f(t_i)$ is a continuous monotonic increasing or decreasing function of time and the residuals ε_i can be assumed to be from the same distribution with zero mean. It is therefore assumed that the variance of the distribution is time invariant.

This test is directly analogous to regression when the test for significance of the correlation coefficient is also the significance test for a simple linear regression. Mann-Kendall trend test requires no normality assumptions but there must be no serial correlation in the dependent values Y, i.e., counts of typhoid fever, which ensures the validity of the P-value.

Hypothesis of Mann-Kendall Trend Test

H_0: Count of typhoid fever cases over the study period is independently distributed.

H_1: There exists a monotonic trend in the data collected on typhoid fever for the study period in the district.

Test Statistic of Mann-Kendall Trend Test

The test statistic for the Mann-Kendall Trend Test according to Frei and Schär (2001), and Zhang, et al. (2004) is given by:

$$S = \sum_{i<k} sign\,(X_k - X_i) \text{With sign (X) =} \begin{cases} 1 & X > 0 \\ 0 & X = 0 \\ -1 & X < 0 \end{cases} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

However, for a large sample (n>8) S is normally distributed with

E(S) ……. …. … … … … … … … … (3)

$$\text{Var(S)} \approx \frac{n(n-1)(2n+5)}{18} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

Also, mutually independent residuals (no serial correlation) require a standardized test statistic (Z) which is compared to normal distribution. However, correction of Var (S) is necessary if there are ties. Thus,

$$\text{Standardized test statistic (Z) =} \begin{Bmatrix} \frac{(\mathrm{s}-1)}{\sqrt{\mathrm{var\ (s)}}} & \mathrm{s} > 0 \\ 0 & s = 0 \\ \frac{(s+1)}{\sqrt{var(s)}} & s < 0 \end{Bmatrix} \quad \ldots \quad \ldots \quad \ldots \quad \ldots (5)$$

Poisson Regression

Poisson regression which is based on Poisson distribution is a model that is used for the analysis of data set whenever the response variables (monthly counts of typhoid fever) are made up of positive integers of rare event. In other words, Poisson regression is used to express the log outcome rates as a linear function of set of predictors (gender, years and demographic age grouping) (Cameron and Trivedi, 1996). Mathematically, the Poisson distribution is:

$$P(Y=y) = \frac{e^{-\mu}\mu^{y}}{y!} \quad , \quad \text{y = 0, 1, 2… n and } \mu > 0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

The logarithm of the response variable (counts of typhoid fever) is linked to a linear function of explanatory variable (gender, years and demographic age grouping of typhoid) cases in the district. That is:

$$\text{Log}_e(\text{Y}) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p$$

$$\Longrightarrow \text{Y} = e^{\beta 0} . e^{\beta 1\, X 1} . e^{\beta 2 X 2} \ldots e^{\beta p X p} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

Where, β_0= constant or intercept and $\beta_1, \beta_2, \ldots, \beta_p$ are the coefficients of predictors (e.g. Gender, years and demographic age grouping of typhoid clients). However, for rates, events occur over time (or space), and the length of time (or amount of space) can vary from observation to observation which the model takes into accounts, Y = count (e.g., number of typhoid cases reported). The *t* refers to index of the time or space (e.g., monthly bases, the typhoid data was collected in the district for the study period). The sample rate of occurrence is Y/t and that of expected value of the rate is:

$$\text{E(Y/t)} = \frac{1}{t} E(Y) = \mu / t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

Therefore, the Poisson log linear regression model for the expected rate of the occurrence of events is:

$\log(\mu/t)=a+\beta x$ … … … … … … … … … (9)

$\text{Log}(\mu)-\log(t)=a+\beta x \Longrightarrow \log(\mu)=a+\beta x+\log(t)$ … … … … (10)

Where, the term "-log(t)" is an adjustment term referred to as an "offset" and each individual may have a different value of it.

Obviously, it is important to admit that Poisson regression is a multiplicative model in parameters. Thus, Poisson log linear regression model with a log link for rate data is:

$\log(\mu/t)=a+\beta x \mu/t=e^{a}e^{\beta x}$ $\mu=te^{a}e^{\beta x}$ … … … … … … … … 11)

Model Statement

The following models were used to estimate the effects of typhoid fever as well as the rate at which typhoid fever occurred within the study period in the district.

i. Log(counts i)=$\beta_0+\beta_1 Gender$ … … … … … … (12)
   Where gender stands for male and female, the counts of typhoid fever was made within the study period in the district.
ii. Log(counts i)=$\beta_0+\beta_1 a_{1i}+\beta_2 a_{2i}+\ldots+\beta_p a_{pi}$, i=1,2,3,…9, … … (13)
iii. wherea_1= Age category of typhoid clients 1-4years,…,a_9= Age categoryof typhoid clients 70+ years

However, model 3 below seeks to investigate the rate at which typhoid fever disease occurred in Saboba district.

iv. Log(counts) =$\beta_0+\beta_1 t_1+\beta_2 t_2+\ldots+\beta_p t_p$ … … … … (14)
   where β_0 is the intercept and $\beta_1, \beta_{2,}, \ldots, \beta_p$ are the specific amount typhoid fever occurred in the district from year to year with respect to the above mentioned study period and $t_i$is the time (yearly) based, estimating the rate at which typhoid fever occur in the district within the study period. Thus,
   $t_1=\begin{cases}1 & year\ \ 2009\\ 0 & otherwise\end{cases}$,…,$t_5=\begin{cases}1 & year\ \ 2013\\ 0 & otherwise\end{cases}$ … … (15)

Also, considering the rate of occurrence of typhoid fever given demographic age grouping above,

$a_1=\begin{cases}1 & if age\ 1-4 years\\ 0 & otherwise\end{cases}$,…,$a_9=\begin{cases}1 & if age\ 70+\ \ years\\ 0 & otherwise\end{cases}$ … … (16)

The above means that, the expected value of counts (typhoid cases) depends on both t and x, both of which are observations.

From the above, the average counts of the typhoid cases in the district for the study period must be equal to its variance, otherwise, over-dispersion or under-dispersion occurs which violates the equal mean-variance assumption of Poisson distribution. In that case, the Poisson regression is no longer appropriate; instead, the negative binomial regression model, which has additional parameter, would be used to correct the inequality that might exist between the mean and the variance of the counts (typhoid fever cases) in the district.

Negative Binomial Regression

The negative binomial regression is another distribution that is concentrated on the nonnegative integers. Unlike the Poisson regression, negative binomial model has an additional parameter such that the variances can exceed the mean. Thus, the Negative Binomial distribution is therefore expressed as:

$$E(Y) = \mu \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

$$Var(Y) = \mu + D\mu^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

Where D is the dispersion parameter. Greater heterogeneity in the Poisson means results in a large value of D. As $D \rightarrow 0$, $Var(Y) \rightarrow \mu$ and the Negative Binomial distribution converge to the Poisson distribution, hence, the farther D falls above 0, the greater the over-dispersion relative to Poisson variability.

Model Diagnostics

The estimates of the Poisson regression are subject to diagnostic test to identify the possible violations of assumptions of the Poisson distribution for modeling typhoid cases in the district. The purpose of the diagnostic test is to determine whether the variances are too small or too large. This could be achieved by plotting the residuals of typhoid data collected versus its means at different levels of the predictor variables (gender, years and demographic age grouping of typhoid clients).

Model Fitting

The model fitting refers to the estmation of Poisson regression coefficients or parameters. Loglinear Poisson model is a generalized linear model with Poisson error and link log. The prarmeter estimation of typhoid cases in the Saboba districts was based on Maximum Likelihood Estimation(ML). However, Maximum Likelihood estimation would still be useful for Negative Binomial regression paraters estimation in case the assumption(s) of the proposed Poisson model is violated. A negative binomial modelwould be used to validate the Poisson model.

RESULTS AND DISCUSSIONS

Mann Kendall Trend Analyses

To accomplish the objective for trend analysis and the prevalence of typhoid fever based on some demographic parameters - age grouping, gender and years of study in Saboba district, the Mann-Kendall's trend analysis was carried out.

Table 1.1: Mann Kendall Trend Statistic for Counts of Typhoid by Age group

Kendall's Tau-b	
Tau-b	0.1050
ASE	0.0047
95% Lower Conf Limit	0.0957
95% Upper Conf Limit	0.1143

ISSN: 2026-6022 ISSN-L: 2026-6022
VOL. 1, No. 3(1), July, 2016
Published by Africa Development and Resources Research Institute

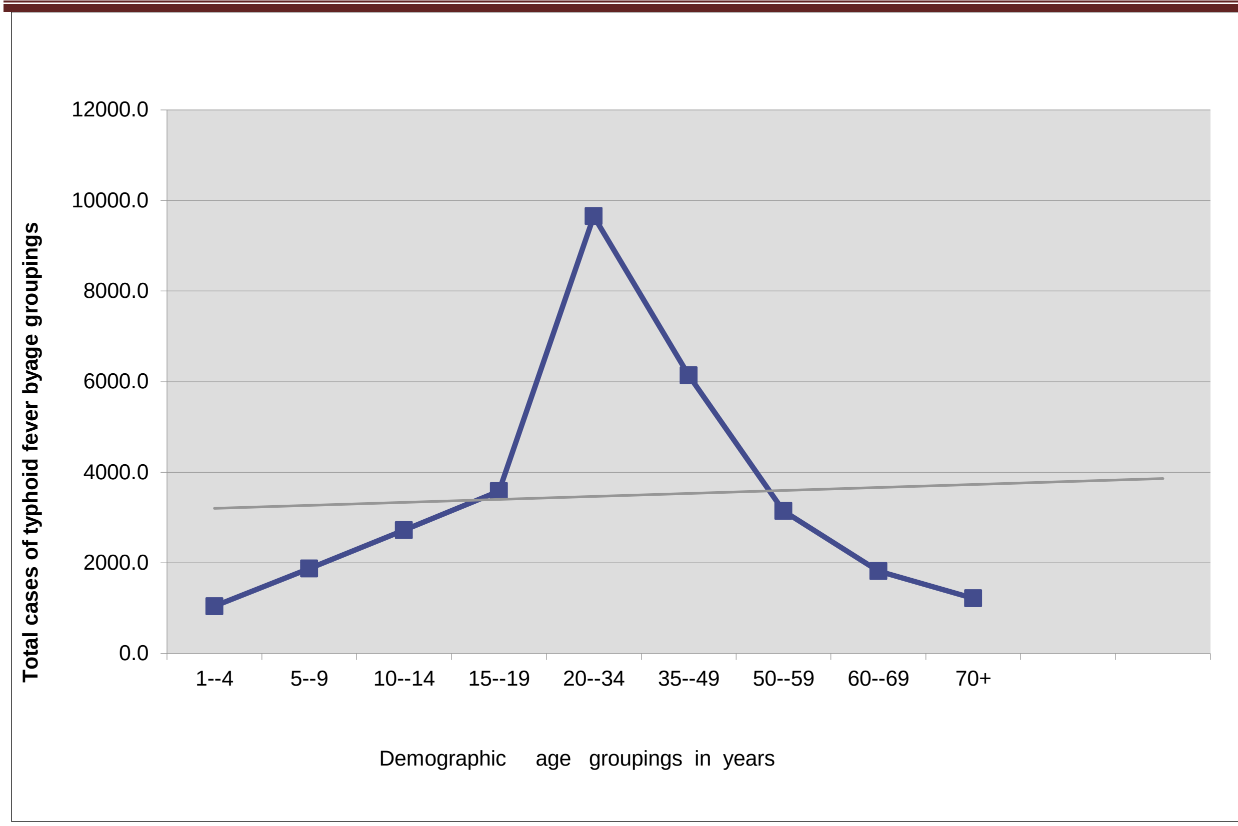

Figure 1.1: Trend for Counts of Typhoid by Age Group

From Table 1.1 the null hypothesis (H_o) of no monotonic trend in the typhoid incidence in the district cannot to be rejected at the significance level of 5%. This implies the Kendall's Tau-b of 0.1050 is statistically different from zero (0). Furthermore, the positive sign of the Kendall's Tau-b value is suggestive of a positive trend (upward trend) of demographic age groupings. That is, an upward trend from 1-4 year (reference or baseline) to 70+ years (adults) and vice versa.

The Kendall's Tau-b statistic was therefore suggesting that typhoid fever infection was slightly higher among adults of age group (70+) years than the children of age group (1-4) years within the study period of 2009 to 2013 in the district.

1.2 Trend for Counts of Typhoid Cases by Year

Table 1.2: Mann Kendall Trend Statistic for Counts of Typhoid Cases by Year

Kendall's Tau-b	
Tau-b	-0.3013
ASE	0.0041
95% Lower Conf Limit	- 0.3093
95% Upper Conf Limit	-0.2932

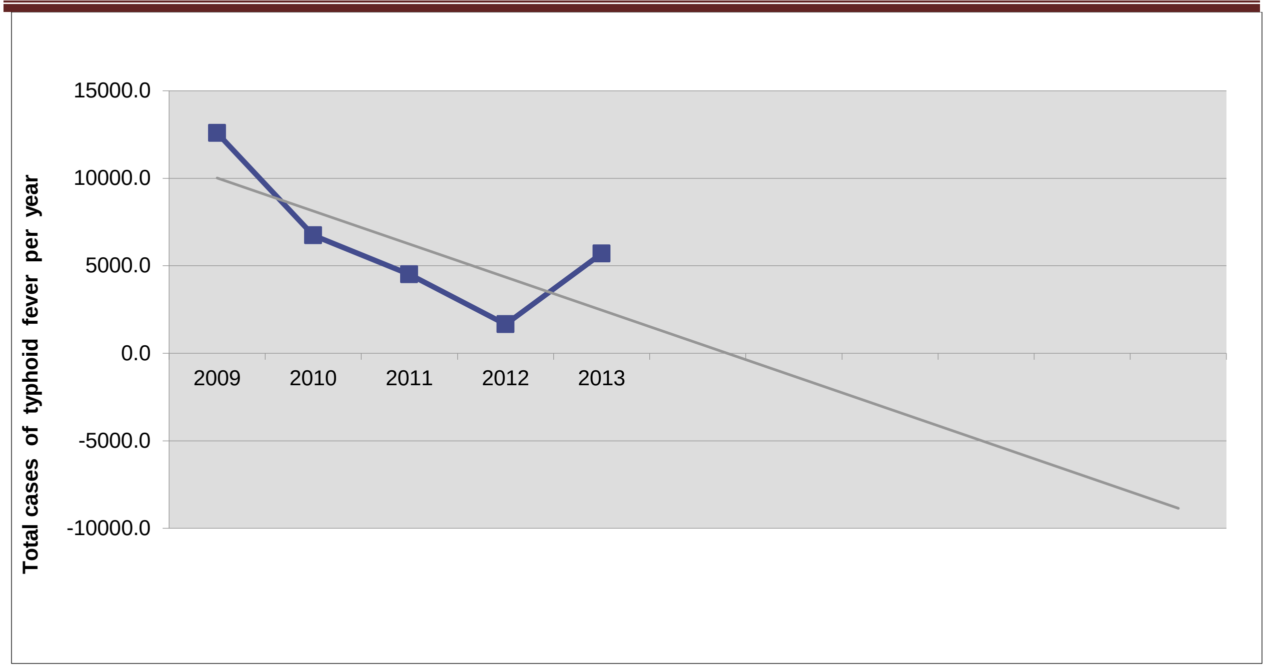

Figure1.2: Trend for Counts of Typhoid Cases (2009 – 2013)

Table 1.2 and

Figure1.2 show the results of the Mann-Kendall's trend analysis for years under review. Generally, a downward trend is observed of the typhoid cases reported in Saboba district from 2009 to 2013. The year 2009 as a baseline of the study with Kendall's Tau-b statistic being negative (-0.3013) is an indication that typhoid infection or the incidence in the district has been decreasing from year 2009 to the year 2012. Between 2013 and 2014, however, the incidence of typhoid assumed an upward trend.

Modeling and Criteria for Assessing Model Goodness of Fit

Table 1.3: Goodness of Fit Statistics for the Poisson Regression Model

Models	Deviance (Value/DF)
1. Log (counts_ typhoid) = $\beta_0 + \beta_i Gender$	242.9796
2. Log (counts_ typhoid) = $\beta_0 + \beta_i Agegroup$, i =1,…,9	28.8976
3. Log (counts_ typhoid) =$\beta_0 + \beta_i Year$,i =1,…,5	33.454

Table 1.4: Parameter Estimates of the Selected Proposed Poisson Model

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr>ChiSq
Intercept (Gender)		1	3.3704	0.0080	3.3548	3.3861	178450	<.0001
Intercept (Age group)		1	2.3199	0.0286	2.2638	2.3760	6571.53	<.0001
Intercept (Year)		1	3.2729	0.0132	3.2470	3.2989	61059.3	<.0001
Gender	M	1	-0.0136	0.0113	-0.0358	0.0086	1.44	<0.2301
Gender	F	0	0.0000	0.0000	0.0000	0.0000	.	.

Age group	1-4	1	-0.1557	0.0421	-0.2382	-0.0731	13.64	<0.0002
Age group	5-9	1	0.4284	0.0368	0.3563	0.5005	135.69	<.0001
Age group	10-14	1	0.8024	0.0344	0.7349	0.8699	542.86	<.0001
Age group	15-19	1	1.0763	0.0331	1.0113	1.1412	1054.77	<.0001
Age group	20-34	1	2.0675	0.0304	2.0080	2.1270	4633.11	<.0001
Age group	35-49	1	1.6153	0.0313	1.5539	1.6767	2657.51	<.0001
Age group	50-59	1	0.9468	0.0337	0.8807	1.0129	788.55	<.0001
Age group	60-69	1	0.3992	0.0370	0.3267	0.4717	116.43	<.0001
Age group	70+	0	0.0000	0.0000	0.0000	0.0000	.	.
Year	2009	1	0.7924	0.0160	0.7611	0.8236	2463.31	<.0001
Year	2010	1	0.1692	0.0180	0.1340	0.2045	88.50	<.0001
Year	2011	1	-0.2339	0.0199	-0.2730	-0.1949	137.82	<.0001
Year	2012	1	-1.2367	0.0279	-1.2914	-1.1819	1961.53	<.0001
Year	2013	0	0.0000	0.0000	0.0000	0.0000	.	

Modeling the Occurrence of Typhoid in Saboba District, 2009-2013.
The deviance values for all the three proposed Poisson models are presented in Table 1.3. The deviance values are nowhere near one (1). These indicate that there is over-dispersion in the data set of typhoid incidence in Saboba district. Over-dispersion exist because of heterogeneity in the data set meaning that the fitted variances for the three models are each larger than their means in the typhoid incidence date set.

This violates one of the assumptions of Poisson distribution, namely, that the mean and the variance of the distribution are equal. For this reason, the Poisson regression is inappropriate for this study. The failure of the dataset to satisfy the equal mean-variance assumption of Poisson distribution necessitated the use of the Negative Binomial regression which has additional parameter. It was used to pool down the values of the deviance close to one (1). The adoption of the Negative Binomial regression was aimed at correcting the problem of over-dispersion and thereby making the model to fit the data well in order to achieve the objectives of the study.

Comparing the Poisson and Negative Binomial Regression Models
Table 1.5: Assessment Criteria for Poisson and Negative Binomial Regression Models

Deviance Statistic for the two models		
Parameter	**Poisson models**	**Negative Binomial Models**
Gender of typhoid clients	42.9796	1.2009
Demographic age groupings	28.8976	1.1973
Years of the study	33.4547	1.1929

The goodness of fit results for the Poisson and Negative Binomial Regression Models are shown in Table 1.5. It is clear that the Negative binomial regression model fits the occurrence of typhoid incidence data better than the Poisson regression model.

ADRRI JOURNAL OF MEDICAL AND BIOMEDICAL RESEARCH
ISSN: 2026-6022 ISSN-L: 2026-6022
VOL. 1, No. 3(1), July, 2016
Published by Africa Development and Resources Research Institute

First, the deviance values for the Poisson model are much larger than 1, which indicates an over-dispersion in the data set implying Poisson model does not fit the dataset appropriately. However, the deviance values for the Negative Binomial models are all close to one (1). These indicate that the Negative Binomial models are appropriate for the typhoid fever incidence data in the district. Table 1.5, shows the deviance statistic comparison of the models. Table 1.5 presents the parameter estimates from the negative binomial models.

Modeling the Typhoid Fever Using the Negative Binomial Regression Model

Table 1.6: Negative Binomial Regression Model Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr>ChiSq
Intercept (Gender)		1	3.3568	0.0579	3.2434	3.4702	3365.61	<.0001
Intercept (Age grouping)		1	2.3199	0.1087	2.1069	2.5330	455.45	<. 0001
Intercept (Years)		1	3.2729	0.0823	3.1116	3.4343	1580.45	<.0001
Gender	F	1	0.0136	0.0818	-0.1468	0.1740	0.03	0.8681
Age group	1-4	1	-0.1557	0.1542	-0.4578	0.1465	1.02	0.3127
Age group	5-9	1	0.4284	0.1528	0.1289	0.7279	7.86	0.0051
Age group	10-14	1	0.8024	0.1523	0.5040	1.1008	27.78	<.0001
Age group	15-19	1	1.0763	0.1520	0.7784	1.3741	50.16	<.0001
Age group	20-34	1	2.0675	0.1514	1.7708	2.3642	186.51	<.0001
Age group	35-49	1	1.6153	0.1516	1.3182	1.9124	113.56	<.0001
Age group	50-59	1	0.9468	0.1521	0.6487	1.2449	38.75	<.0001
Age group	60-69	1	0.3992	0.1529	0.0996	0.6988	6.82	0.0090
Year	2009	1	0.7924	0.1160	0.5650	1.0197	46.64	<.0001
Year	2010	1	0.1692	0.1163	-0.0587	0.3972	2.12	0.1457
Year	2011	1	-0.2339	0.1166	-0.4625	-0.0054	4.02	0.0449
Year	2012	1	-1.2367	0.1183	-1.4684	-1.0049	109.36	<.0001

The proposed models in Table 3.3 would be modeled using the estimates of the Negative binomial regression in Table 3.6 as follows:

1. Log (counts_ typhoid) =$\beta_0 + \beta_i Gender$

⟹ Log (counts_ typhoid) = Log (μ) = 3.3568 + 0.0136(female) + 0(male) … **Model 1**

2. Log (counts_ typhoid) =$\beta_0 + \beta_i Agegroup$, i=1,…, 9

⟹ Log (counts_ typhoid) = Log (μ)= 2.3199 - 0.1557(1-4)yrs + 0.4284(5-9) yrs + 0.8024(10-14) yrs + 1.0763(15-19) yrs + 2.0675(20-34) yrs + 1.6153(35-49) yrs + 0.9468(50-59) yrs + 0.3992(60-69) yrs + 0(70+) yrs … … … … … … … **Model 2**

3. Log (counts_ typhoid) =$\beta_0 + \beta_i Year$,i = 1,…,5

⟹ Log (counts_ typhoid) = Log (μ) = 3.2729 + 0.7924(2009) + 0.1692(2010) - 0.2339(2011) - 1.2367(2012) + 0(2013) … … … … … … … … **Model 3**

Model 1 is not an appropriate model for the purpose of predicting typhoid incidence using gender as an explanatory variable according to Table 3.6, because it is statistically insignificant with associated Pr>Chi-square value (0.8681) exceeding the significance level of 5% . The appropriate and the most reliable models are models 2 and 3. The results of the analysis showed that, the typhoid fever incidence in males was 0.0136 times lower than that of their female (baseline) counterparts. This was found to be $e^{-0.0136}$ = 0.9865, representing the multiplicative effect on the fitted value (mean of typhoid fever) for a unit increase in x, i.e. typhoid patients (males) in Saboba district.

The effect $\hat{\beta}$=- 0.0136 being negative was an indication that the expected counts of typhoid fever in terms of gender (males) in the Saboba district decreases as the typhoid patients(male) continue to increase. This accounts for 99% of all typhoid fever cases reported in Saboba district between the periods 2009 to 2013. This was not statistically significant in view of its associate p-value of 0.8681.It could be concluded that the infection rate of typhoid fever in Saboba district is higher among females, than in males within the years under review.

Regarding the various age groups, the occurrence of typhoid fever was found to be statistically insignificant at the 5% level for (1-4) age group in view of its associate p-value of 0.3127. This was 0.1557 times lower than the other demographic age groups of typhoid patients in this investigation. The effects ($\hat{\beta}$)=- 0.1557= $e^{-0.1557}$ (0.8558) means that the expected counts of typhoid fever in terms of demographic age group (1-4)years in the district decreases as the age group of typhoid patients continue to increase. It accounted for 86% of all typhoid fever cases that was reported in Saboba district between the periods 2009 - 2013.

Considering the period of the study, the occurrence of typhoid fever was found to be statistically insignificant at the 5% level for the year 2010 with the associated p-value of 0.1457. This was 0.1692 times higher than the base year of 2013. The effects ($\hat{\beta}$) =0.1692= $e^{0.1692}$ (1.1844) means that the mean counts of typhoid fever in the year2010 increases with time.

However, the occurrence of typhoid fever was found to be statistically significant at 5% level for the year 2009 with associated p-value of <.0001. This was 0.7924 times higher than the year 2013(baseline). The effects ($\hat{\beta}$) = 0.7924= $e^{0.7924}$ (2.2087) means that the expected counts of typhoid fever in the year 2009 increases over the years under study. However, the effects of typhoid fever incidence in the district was found to be 0.2339 and 1.2367 times lower within the years 2011, and 2012, respectively, than the base year 2013. They were all statistically significant at the 5% level with associated p-value of 0.0449 and < 0.0001.

The effects $\hat{\beta}$ (-0.2339 and -1.2367) for the years 2011 and 2012 of the study period were less than zero (0) or negative. These mean that the mean counts of typhoid fever for the years 2011 and 2012 in the district decreases by every 1-unit increase in years within 2009 to 2013.

Estimating the Rates of Typhoid Fever Cases

Table 1.7: Rate of Occurrence of Typhoid Fever Given Years of Incidence

t_i (year)	$= \boldsymbol{\beta_0 + \beta_1 t_i}$, i =1,2,…,5	Rate of occurrence
t_1(2009)	= 3.2729 + 0.7924(1)	= 4.0653
t_2(2010)	= 3.2729 + 0.1692(1)	= 3.4421
t_3(2011)	= 3.2729 - 0.2339 (1)	= 3.039

t_4(2012)	= 3.2729 - 1.2367(1)	= 2.0362
t_5(2013)_baseline	= 3.2729 + 0 (1)	= 3.2729

From Table 1.7, the rate of typhoid fever infection in the district was high in the year 2009, directly followed by the year 2010 and the base year 2013. The year 2012 recorded the least infectious rate of typhoid fever in the Saboba district within the study period. Also, **Error! Reference source not found.**, was used to estimate the rates at which typhoid fever occurred within the demographic age grouping of the study.

Table 1.8: Rate of Occurrence of Typhoid Fever Given Age Groupings of Typhoid Clients

a_i **(Age group)**	$= \boldsymbol{\beta_0} + \boldsymbol{\beta_1 a_i}$ **,i =1,2,…,9**	**Rate of occurrence**
a_1(1-4)yrs	= 2.3199 - 0.1557(1)	= 2.1642
a_2 (5-9)yrs	= 2.3199 + 0.4284(1)	= 2.7483
a_3(10-14)yrs	= 2.3199 + 0.8024(1)	= 3.1223
a_4(15-19)yrs	= 2.3199 + 1.0763(1)	= 3.3962
a_5(20-34)yrs	= 2.3199 + 2.0675(1)	= 4.3874
a_6(35-49)yrs	= 2.3199 +1.6153(1)	= 3.9352
a_7(50-59)yrs	= 2.3199 + 0.9468(1)	= 3.2667
a_8(60-69)yrs	= 2.3199 + 0.3992(1)	= 2.7191
a_9((70+)_baseline	= 2.3199 + 0 (1)	= 2.3199

From Table 1.8, the rate of typhoid fever infection in the district was high among the age group (20-34) years, which was directly followed by the age group (35-49) years and age group (15-19) years. However, the age group (1-4) years representing children, and the adult age (70+) years had the least infectious rate of typhoid fever in the district within the study period.

CONCLUSIONS

It was found that there exist a downward (negative) trend of typhoid infections in the district within the study period (years). But there was an insignificant trend or no trend of typhoid infections for demographic age groupings of typhoid clients in Saboba district for the above mentioned study period.

The infection rate of typhoid fever incidence in Saboba district for the study period, 2009 to 2013 was independent of gender of typhoid subjects as its p-value of 0.8681 was greater than the significant level of 0.05.

The rate of occurrence of typhoid fever in the Saboba district was significantly high among the economically active age group namely (20-34) and (35-49).

The rate of typhoid fever incidence in Saboba district was high in the year 2009, followed by a sharp decreased over the years until 2012 and thereafter the incidence of typhoid fever assumed an increasing trend.

RECOMMENDATIONS

i. Since typhoid fever infection in the Saboba district, with regard to 2009 to 2013, is independence of gender, it is recommended that, the health education programs and the Saboba district health policies should not be gender bias.

ii. Most of the affected groups were people among the demographic age groupings 20-34, 35-49 and 50-59, years of age, who constitute the working force of the country and, for that matter, the District Health Directorate, should intensify its campaign on the effects of typhoid fever.
iii. The education on eating hot food, the use of hygienic water through boiling, use of chlorinated water or using alum and general environmental cleanliness such as clearing of bushes, cleaning of choked gutters and getting rid of stagnant water.
iv. Again, further studies should be carried out frequently in the Saboba district to monitor the incidence of typhoid fever, so that appropriate measures and strategies could be adopted to curtail its spread.

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