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Statistical Analysis of Risk Factors Associated with Anaemia among Children Under Five Years in Western Ghana

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Abstract: ***This study examined the relation between Anaemia and some risk factors among children under the ages of five years in the Tarkwa Nsuaem municipality, a mining community in Western Ghana. The risk factors considered were Malaria, Diarrhoea and Malnutrition. The examination was achieved by formulating models using the risk factors as the explanatory variables of anaemia through which the contribution of each risk factor to the prevalence of anaemia was identified. Analysis was performed in three phases, thus, on females, males and the overall cases of anaemia cases reported in the Tarkwa Nsuaem municipality. The results from the overall cases indicate that the prevalence of anaemia among children under five years in the municipality is highly attributed to the incidence of malnutrition (10.50), followed by diarrhoea (0.74) and malaria (0.08).***

Keywords: Anaemia, Malaria, Diarrhoea, Malnutrition, Regression and VIF

1. Introduction

Anaemia continues to be a public health problem worldwide. The most up-to-date global estimates of childhood anaemia indicate that 293.1 million children under five years are anaemic worldwide, and 28.5% of those are located in sub-Saharan Africa (Anon., 2008). Anaemia in infancy and childhood is associated with reduced cognitive development, growth, immune function and survival (Ricardo and Archie, 2011).Anaemia is usually multifactorial in origin, and malaria, diarrhoea and malnutrition are said to be contributing factors (Ricardo and Archie, 2011; Semba *et al*., 2007). According to Ricardo and Archie (2011), the prevalence of mild, moderate and severe anaemia was 28%, 65% and 7% respectively in Ghana with southern Ghana recording the highest number of anaemic children.

In Tarkwa Nsuaem Municipality, Ghana, anaemia is ranked among the top diseases that threaten the lives of children under five. In the municipality, fewer than five children died of anaemia out of 234 cases recorded in 2008, 167 in 2009 and 350 in the year 2010 (Anon., 2011). It is therefore imperative to research whether these risk factors (malaria, diarrhoea and malnutrition) influence the prevalence of anaemia in children under five years in the Municipality. And if so, examine the contribution of each risk factor to the prevalence of Anaemia in the municipality.

In view of this, the research seeks to formulate models for the risk factors of anaemia and identify the extent to which each of these risk factors influence the prevalence of anaemia in the Tarkwa Nsuaem Municipality of Ghana.

2. Materials and Method

2.1 Data Acquisition

To examine contribution of the risk factors to the prevalence of Anaemia in children under five years in the Tarkwa Nsuaem Municipality, secondary data for children under five years were obtained from the Health Information Unit at Tarkwa Nsuaem Municipality. The data was made up of reported cases of anaemia, malaria, diarrhoea and malnutrition diseases, spanning from 2006 to 2014.

2.2 Descriptive Analysis of Data

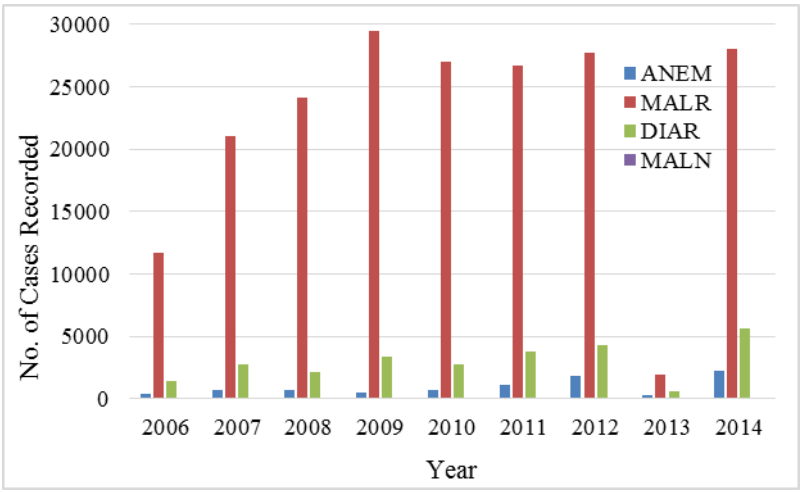

Figure 1: Overall Anaemia Cases Reported

It was observed from fig.1, that reported cases of anaemia as well as the risk factors for female and male children under five years in the Tarkwa municipality increased in 2006 to 2007 and also from 2009 to 2012. Similar trend is shown in diarrhoea and malaria cases reported. The overall reported cases of anaemia and the risk factors observed, malaria recorded the highest number of cases throughout the years, followed by diarrhoea. Anaemia remained the third highest reported cases in all the years with malnutrition showing only abysmal number of cases reported from 2006 to 2014.There was also an increase in almost all the diseases from the year 2006 to 2009. The number of cases once again increased in 2011 as well. However, the number of cases for all reported cases decreased drastically in the year 2013 and again experienced a massive increase in 2014.

1.3 Multiple Linear Regression

The general form of a multiple regression is:

$$y_t = \beta_0 + \beta_1 x_{1,t} + \beta_2 x_{2,t} + \cdots + \beta_q x_{q,t} + \varepsilon_t \qquad (1)$$

where y_t is the variable to be forecast and $x_{1,t},\ldots,x_{q,t}$ are the q predictor variables. The coefficients $\beta_1,\ldots,\beta_q$ measure the effect of each predictor after taking account of the effect of all other predictors in the model. Thus, the coefficients measure the marginal effects of the predictor variables. When forecasting, the general assumption required for the errors $(\varepsilon_1,\ldots,\varepsilon_t)$ are as follows:

1) $E(\varepsilon_i) = 0,$ for all $i = 1,2,\ldots,t.$ (linearity)
2) $\text{var}(\varepsilon_i) = \sigma^2,$ for all $i = 1,2,\ldots,t.$ (constant variance)
3) $\text{cov}(\varepsilon_i, \varepsilon_j) = 0,$ for all $i \neq j.$ (uncorrelated error terms)
4) $\varepsilon_i \sim N(0,1)$ (error terms be normally distributed)

3. Results and Discussions

Table 1shows the correlation between anaemia and the risk factors reported. As observed, all the risk factors had positive relation with anaemia. This implies the prevalence of anaemia is positively associated to these risk factors considered in the study. Also, diarrhoea showed a significant correlation implying that its association with the prevalence on anaemia in the municipality is substantial. This confirms the findings of Semba *et al*. (2008).

Table 1: Correlation between Anaemia and Risk Factors

	Anaemia	Malaria	Diarrhoea	Malnutrition
Anaemia	1.0000			
Malaria	0.5612 (0.1159)	1.0000		
Diarrhoea	0.8983 (0.0009)	0.8123 (0.0078)	1.0000	
Malnutrition	0.0885 (0.8210)	0.5669 (0.1114)	0.1564 (0.6878)	1.0000

3.1 Analysis on Female Anaemia Cases Reported

Table 2 shows the descriptive statistics of the reported cases of anaemia and the risk factors of female children under five years in the Tarkwa municipality.

Table 2: Descriptive Statistics of Female Reported Cases

Variable (Cases Reported-Females)	Initials	Mean	Standard Deviation	Min	Max
Anaemia	$ANEM_F$	460.11	341.12	130.00	1104.00
Malaria	$MALR_F$	10734.11	4527.30	940.00	14565.00
Diarrhoea	$DIAR_F$	1409.22	786.72	283.00	2907.00
Malnutrition	$MALN_F$	19.78	15.82	1.00	49.00

Using the values of the female children reported cases ($ANEM_F$) as the dependent variable and the risk factors ($MALR_F$, $DIAR_F$ and $MALN_F$) as the predictors, the result of the analysis is shown in Table . As observed, the p-value from the F-test (<0.01), shows that the model is statistically significant. Also, all the parameters are significant except the constant term, which is an indication of how each risk factor contributes significantly to the model. The VIF values of all variables are close to 1.00, hence an indication of a nearly complete elimination of multicollinearity.

Table 3: Summary of Analysis

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|	VIF
Intercept	42.48	80.18	0.53	0.62	0.00
$MALR_F$	-0.06	0.02	-4.01	0.01	4.89
$DIAR_F$	0.65	0.08	8.52	<0.01	3.64
$MALN_F$	8.30	2.70	3.08	0.03	1.85

F-Value=37.78, P-Value=<0.01, R^2 Adjusted=0.9324

Table 3shows the descriptive statistics of the reported cases

Regarding the test of assumptions of the model,
Table 4 shows the test on the assumptions regarding the regression model in Table 3. As observed in 4, all the assumptions of the model were satisfied, indicating that the model is adequate.

Table 4: Test of Assumptions on Model

Assumption	Hypothesis	Statistic (P-Value)
Linearity (Runs)	H_0: $E(\varepsilon_i)$=0 H_1: $E(\varepsilon_i) \neq 0$	0.0000
Normality (Shapiro-Wilk)	H_0: Normally distributed H_1: Not normally distributed	0.8447 (0.0651)
Serial Correlation (Box-Pierce)	H_0: True autocorrelation=0 H_1: True autocorrelation ≠0	0.1827 (0.6691)
Homoscedasticity (Breusch-Pagan)	H_0: Constant variance H_1: Non-constant variance	1.4233 (0.7001)

3.2 Analysis on Male Anaemia Cases

of anaemia and the risk factors of male children under five years in the Tarkwa municipality.

Table 3: Descriptive Statistics of Male Reported Cases

Variable (Cases Reported-Males)	Initials	Mean	Standard Deviation	Min	Max
Anaemia	$ANEM_M$	502.44	341.29	136.00	1181.00
Malaria	$MALR_M$	11228.67	4747.30	1013.00	14886.00
Diarrhoea	$DIAR_M$	1563.56	746.40	299.00	2723.00
Malnutrition	$MALN_M$	16.11	11.65	1.00	36.00

Using the values of the male children reported cases ($ANEM_M$) as the dependent variable and the risk factors ($MALR_M$, $DIAR_M$ and $MALN_M$) as the predictors, the result of the analysis is shown in Table 4. As observed, the p-value from the F-test (<0.01), shows that the model is statistically significant. Also, two out of four (($MALR_M$, $DIAR_M$) of the parameters are significant, which is an indication of how $MALR_M$,$DIAR_M$ contribute significantly to the prevalence of anaemia in male children in the municipality. The VIF values of all variables are less than 10, indicating a minimal and negligible level of multicollinearity in the model. Among the risk factors considered, malnutrition was seen to account for the highest factor of anaemia. This could be attributed to the fact that micronutrient deficiency is the main cause of anaemia in children, and its prevalence is higher in malnourished children. Low dietary iron, decreased absorption of dietary iron, and malabsorption syndrome are the causes of iron deficiency anaemia especially in the poor section of society (Gupta, 2017).

Table 4: Summary of Analysis

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|	VIF
Intercept	-27.62	103.74	-0.27	0.80	0.00
$MALR_M$	-0.08	0.03	-3.13	0.03	9.95
$DIAR_M$	0.82	0.14	5.78	<0.01	6.98
$MALN_M$	11.32	6.09	1.86	0.12	3.12

F-Value=22.40, P-Value=<0.01, R^2 Adjusted=0.8892

Regarding the test of assumptions of the model,
Table 5shows the test on the assumptions regarding the regression model in **Table 4**. As observed in **Table 5**, all the assumptions of the model were satisfied, indicating that the model is adequate.

Table 5: Test of Assumptions on Model

Assumption	Hypothesis	Statistic (P-Value)
Linearity (Runs)	H_0: $E(\varepsilon_i)$=0 H_1: $E(\varepsilon_i) \neq 0$	0.0000
Normality (Shapiro-Wilk)	H_0: Normally distributed H_1: Not normally distributed	0.9356 (0.5363)
Serial Correlation (Box-Pierce)	H_0: True autocorrelation=0 H_1: True autocorrelation ≠0	1.5155 (0.2183)
Homoscedasticity (Breusch-Pagan)	H_0: Constant variance H_1: Non-constant variance	1.6321 (0.6521)

3.3 Analysis on Overall Anaemia Cases Reported

Table 6 shows the descriptive statistics of the overall reported cases of anaemia and the risk factors of children under five years in the Tarkwa municipality.

Table 6: Descriptive Statistics of Overall Reported Cases

Variable (Cases Reported-Overall)	Initials	Mean	Standard Deviation	Min	Max
Anaemia	ANEM	962.56	681.57	266.00	2285.00
Malaria	MALR	21962.78	9258.00	1953.00	29451.00
Diarrhoea	DIAR	2972.78	1525.29	582.00	5630.00
Malnutrition	MALN	35.89	26.43	2.00	85.00

Using the values of the male children reported cases (ANEM) as the dependent variable and the risk factors (MALR,DIAR and MALN) as the predictors, the result of the analysis is shown in

Table 7. As observed, the p-value from the F-test (<0.01), shows that the model is statistically significant. Moreover, all the parameters are significant except the constant term, which is an indication of how each risk factor contribute significantly to the model. The VIF values of all variables are less than 10, indicating a minimal and negligible level of multicollinearity in the model.

Table 7: Summary of Analysis

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|	VIF
Intercept	26.53	159.91	0.17	0.87	0.00
MALR	-0.08	0.02	-4.19	0.01	9.95
DIAR	0.74	0.09	8.18	<0.01	6.98
MALN	10.50	3.71	2.83	0.04	3.12

F-Value=37.82, P-Value=<0.01, R^2 Adjusted=0.9325

Regarding the test of assumptions of the model,
Table **8** shows the test on the assumptions regarding the regression model in
Table **7**. As observed in
Table **8**, all the assumptions of the model were satisfied, indicating that the model is adequate. Hence, the model for the overall anaemia reported cases of children under five years in the Tarkwa municipality is given as in Equation (2).

$$ANEM = 26.53 - 0.08 * MALR + 0.74 * DIAR + 10.50 * MALN \quad (2)$$

Table 8: Test of Assumptions on Model

Assumption	Hypothesis	Statistic (P-Value)
Linearity (Runs)	H_0: $E(\varepsilon_i)=0$ H_1: $E(\varepsilon_i) \neq 0$	0.0000
Normality (Shapiro-Wilk)	H_0: Normally distributed H_1: Not normally distributed	0.9404 (0.5858)
Serial Correlation (Box-Pierce)	H_0: True autocorrelation=0 H_1: True autocorrelation ≠0	0.0300 (0.8625)
Homoscedasticity (Breusch-Pagan)	H_0: Constant variance H_1: Non-constant variance	2.1544 (0.5410)

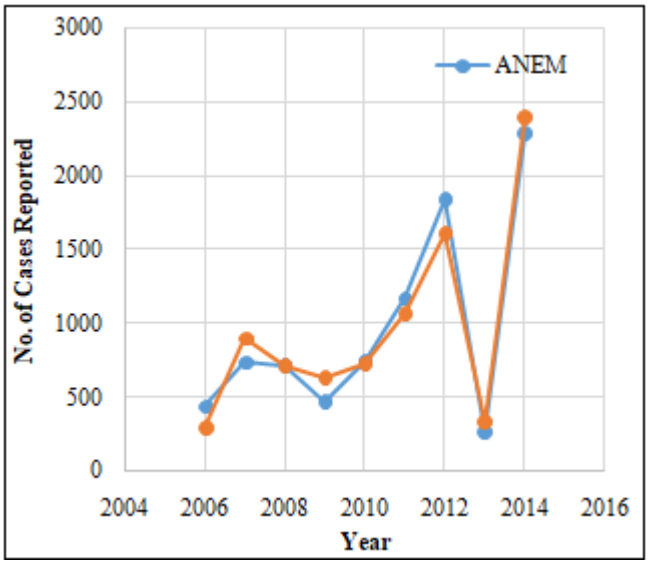

Figure 12: shows the plot of the overall reported cases as well as the predicted values of reported anaemia cases of children under five years in the municipality.

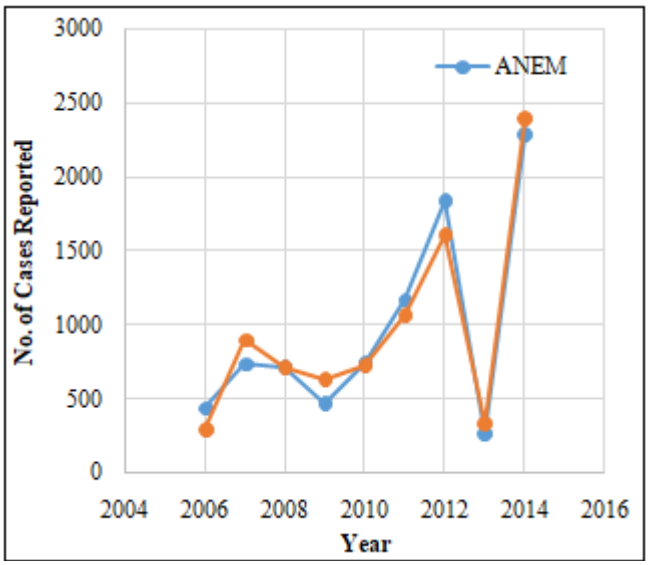

Figure 1: Overall Reported and Predicted Anaemia Cases Children

3.3.1 Discussions

The result from the analysis indicates that, all the risk factors considered in the study were significant contributors to the prevalence of anaemia of children under five years in the municipality. Among these risk factors, malnutrition (10.50) accounted for the highest contributor to anaemia, followed

by diarrhoea (0.74) and malaria (0.08) respectively. A critical observation of the coefficients of the developed model (Equation (2)) indicates that Anaemia cases for children under five years in the municipality is positively related to Diarrhoea (DIAR) and Malnutrition (MALN)whilst negatively to Malaria (MALR).From this interpretation, the positive coefficients of Diarrhoea (DIAR) and Malnutrition (MALN) suggests that a unit increase in these variables would increase the reported anaemia cases of children under five years in the municipality by approximately 0.74 and 10.50 MT respectively. This could be attributed to the fact that; situations such as food insecurity and nutritional deficiencies (poor intake of iron, folate, vitamin A and vitamin B12 are conditions that expedite the prevalence of anaemia ((Castelli *et al*., 2014).

In Fig.2, the plot of the overall reported cases as well as the predicted values of reported anaemia cases of children under five years in the municipality show an increase trend as the years increases. This calls for immediate interventions as may lead to the death of most of the children under five years due to malnutrition, Diarrhoea, Malaria and Malnutrition.

Also, the reported anaemia cases of children under five years in the municipality is bound to decrease by approximately 0.08 if there is a unit increase in Malaria (MALR). This is due to the fact that, malaria-attributable fraction of anaemia may then differ in different settings (Castelli *et al*., 2014). Furthermore, malarial anaemia often coexists with, and is made worse by, other poverty related causes of anaemia, such as malnutrition or intestinal parasites, in complex interrelationships (Naing *et al*., 2013). Chronic and acute inflammation, parasitic infections (mainly malaria and intestinal parasites), haemoglobinopathies (some linked to malaria epidemiology) and other chronic conditions (e.g. chronic kidney disease). Malaria causes Anaemia through hemolysis and increased splenic clearance of red blood cells and cytokine-induced dyserythropoeisis Menendez el at., (2000).

4. Conclusions

This paper sought to examine and formulate models for the risk factors of anaemia and identify the extent to which each of these risk factors influence the prevalence of anaemia in the Tarkwa Nsuaem Municipality of Western Ghana. The findings from the analysis indicate that, all the risk factors considered in the study were significant contributors to the prevalence of anaemia among children under five years in the municipality. Among these risk factors, malnutrition (10.50) accounted for the highest contributor to anaemia, followed by diarrhoea (0.74) and malaria (0.08) respectively. It is therefore recommended that policies regarding nutritional requirements and needs of children in the municipality should be revised and educating mothers on the risk factors of anaemia in children. This will in effect limit the frequency of diarrhoea and malnutrition cases in the municipality and Ghana as a whole. Further research of cases in recent years should be analysed to compare the trends and to forecast anaemia cases in the Municipality.

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