Modeling the Transmission and Control Strategies of Diphtheria
(A Case Study of Isin Local Government Area of Kwara State)

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ABSTRACT
This research work is carried out to study the outspread of Diphtheria among the population understudy; to investigate whether the contact and transmission depend on gender and as well fit a logistic model that will provide important theoretical support for disease control decision making. In this study, Five thousand Questionnaires were administered to some selected people from all the political wards of Isin Local Government area of kwara state while 4975 were retrieved for further analysis. The methods of data analysis used were data exploration, Chi-Square test and logistics regression. Result of the analysis revealed the widespread of diphtheria in the study area of this research is relatively low and the respondent claims that Diphtheria is not common and that is spreading through air and direct contact. Result of the analysis of the Chi- Square shows that contact and transmission of Diphtheria disease is not depend on gender and that gender is independent of the persistence of diphtheria. Analysis of the logistic regression shows that the persistence of Diphtheria is not significant. It was thereby recommended that health Planner should educate people more on the danger Diphtheria may pose and it preventive measures.
Key Word: Contact, Transmission spread and Diphtheria.

I.   INTRODUCTION
Diphtheria is responsible for both endemic and epidemic diseases, and it was first described in the 5th century BC by Hippocrates. Diphtheria manifests as either an upper respiratory tract or cutaneous infection and is caused by the aerobic gram-positive   bacteria, Corynebacterium diphtheria. The infection usually occurs in the spring or winter months. It is communicable for 2-6 weeks without antibiotic treatment. People who are most susceptible to infection are those who are not completely immunized or have low antitoxin antibody levels and have been exposed to a carrier or diseased individual. A carrier is someone whose cultures are positive for the diphtheria species but does not exhibit signs and symptoms. Diphtheria (dif-THEER-e-uh) is a serious bacterial infection that usually affects the mucous membranes of ones nose and throat. Diphtheria is extremely rare in the United States and other developed countries, thanks to widespread vaccination against the disease. However, many countries with limited health care or vaccination options still experience high rates of diphtheria.
Diphtheria can be treated with medications. But in advanced stages, diphtheria can damage the heart, kidneys and nervous system. Even with treatment, diphtheria can be deadly, especially in children.

SIGNIFICANCE OF STUDY
This research work has really shed more light on the study of Diphtheria disease; this disease might appear deadly if proper care is not taken. Diphtheria is a highly contagious infection that affect the nose and throat and sometimes the skin. Diphtheria is spread through an infectious bacteria by cough and sneezes or through close contact with someone who is infected. It is rare in Nigeria but there is risk of contracting it if one travels to some part of the world. This research will she light on the preventive measures that can be implored through the application of vaccines on children before being exposed to Diphtheria infection.

DATA COLLECTION
Use of Questionnaire was adopted as follows
➤ Pilot survey

➤ Proper Survey
➤ Post enumeration survey
The stage of the research project covers:
▪ Designing of questionnaire
▪ Administration of the questionnaire to people
▪ Data were collected, summarized and presented for analysis.
▪ Demographic data were classified based on age, sex, religion, educational qualification, Local Government Area and State of origin.

METHOD OF DATA COLLECTION
The method of data collection refers to the method used in obtaining the information required. Before acquiring the data used for this research work, the questionnaires were administered within Isin Local Government and collected, in which proper analysis was carried out on the questionnaires.

II.   RESEARCH METHODOLOGY
METHOD OF DATA ANALYSIS
CHI SQUARE (χ^2).
The statistical technique used for analyzing the collected data for this research work was CHI SQUARE (χ^2). Chi square is a non parametric statistics which is usually applied in a test involving nominal measurement. It is used to test the independence of two traits or correlation. It is also use to test for goodness fit of statistics frequency, measurements, categorical variables etc. This area of the research work will mainly deal with the gender distribution contact of Diphtheria in Isin local government. The mathematical computation of Chi Square is given as

$$X^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

Where O_{ij} – the observed value
        E_{ij} – the expected value
To calculate expected frequencies, it is estimated by multiplying the sum of each row by the sum of each column and the product divided by the grand total

$$E_{ij} = \frac{row\ total \times column\ total}{grand\ total}$$

The Hypothesis to be used is given as
H_0: Gender is independent
H_1: Gender is dependent
Level of significance
$\alpha = 0.05$

Test statistic: $X^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$

Multinomial Logistic Regression
Multinomial Logistic Regression (MNLR), simply put, is an extension of binary logistic regression with multiple explanatory variables. MNLR is also referred to as the Multinomial Logistics as well as the Polyatomic Logistic Regression, since it is used to model the relationship between a polychromous response variable and a set of independent variables. The polychromous response could be ordinal (ordered categories) or nominal (unordered categories). The MNLR model permits the comparison of more than one contrast simultaneously. In both MNLR and ordinary logistic regression, the impact of predictor variables are explained in terms of the odds ratio. In logistic regression, the categorical response has only two values. Generally, 1 is for success and 0 for failure. Logistic regression uses a logit function to link the probability of success and predictors, and applies maximum likelihood estimation method to estimate parameters. The multinomial logit compares multiple groups through a combination of binary logistic regressions. This allows each category of the dependent variable to be compared to a reference category. Normally, the category with the highest numeric score is chosen as the reference category. As a general rule, when there are, say, n possible levels of the dependent variable, the MNLR model will consist of n − 1 equation.
The analysis would then compare the population that had [0-dose] relative to [2-dose] and population who had [1-dose] relative to [2-dose]. The MNLR model for 3 options for the number of varicella vaccine can be represented by these two logistic models. Let p denote the number of predictors for the binary response Y by x_1, x_2, ….., x_p. The two equations for the MNLR model is given by

$$Log\left(\frac{Pr\,(Y=0)}{Pr(Y=2)}\right) = \beta_{10} + \beta_{11}x_1 + \beta_{12}x_2 + \cdots + \beta_{1p}x_p \qquad 1$$

$$Log\left(\frac{Pr\,(Y=1)}{Pr(Y=2)}\right) = \beta_{20} + \beta_{21}x_1 + \beta_{22}x_2 + \cdots + \beta_{2p}x_p \qquad 2$$

III.   DATA ANALYSIS

Frequency Table

Table 1: Shows the Gender distributions of the respondent

Gender		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	3055	61.4	61.4	61.4
	Female	1920	38.6	38.6	100.0
	Total	4975	100.0	100.0	

Source: Survey 2022 by Sanusi O.A., Ojo O. D. and Onikola I. O.

Table 1 above shows the gender distribution of respondents. The table indicates that male has the highest frequency of 3055(61.4%) while the female respondents were 1920(38.6%).

Table 2: Show the occupation of the respondents

What do you do for a living		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Student	1634	32.8	32.8	32.8
	Self-Employed	1138	22.9	22.9	55.7
	Government Employed	1322	26.6	26.6	82.3
	Retired	881	17.7	17.7	100.0
	Total	4975	100.0	100.0	

Source: Survey 2022 by Sanusi O.A., Ojo O. D. and Onikola I. O.

Table 2 contains the occupational status of respondents used for this study. It can be observed that students has the highest frequency of 1634(32.8%), followed by government employee with frequency of 1322(26.6%), self-employed have a frequency of 1138(22.9%) while retirees have the lowest frequency of 881(17.7%)

Table 3: Shows the commonness of the Diphtheria in the study area

How common is Diphtheria in your District		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not common	2208	44.4	44.4	44.4
	Common	1540	31.0	31.0	75.3
	Very common	1227	24.7	24.7	100.0
	Total	4975	100.0	100.0	

Source: Survey 2022 by Sanusi O.A., Ojo O. D. and Onikola I. O.

Table 3 shows the widespread status of diphtheria in the area of under study. From this table, the highest frequency which is 2208(44.4%) declared that Diphtheria is not common in the area under study, while 1540(31.0%) frequency suggest its common and the lowest frequency of 1227(24.7%) believed the disease is very common.

Table 4: Shows the place where the respondent treated Diphtheria.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Hospital	2268	45.6	45.6	45.6
	Traditional	1480	29.7	29.7	75.3
	Self-Medication	1227	24.7	24.7	100.0
	Total	4975	100.0	100.0	

Source: Survey 2022 by Sanusi O.A., Ojo O. D. and Onikola I. O.

Table 4 shows that many of the respondents that is 2268(45.6%) was used to treat diphtheria in the hospital, frequency 1480(29.7%) treat it in a traditional way while 1227(24.7%) used self-medication in treating the diphtheria.

Table 5: Show the response of the respondents on how the Diphtheria is been spreads

how does Diphtheria highly spread				
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Air and Direct contact	2588	52.0	52.0	52.0
	Air	1637	32.9	32.9	84.9
	Direct contact	750	15.1	15.1	100.0
	Total	4975	100.0	100.0	

Source: Survey 2022 by Sanusi O. A., Ojo O. D. and Onikola I. O.

Table 5 shows that many respondents believed Diphtheria is highly spread through air and direct contact with frequency 2588(52.0%) followed by air alone with frequency 1637(32.9%) while other suggested by direct contact with frequency 750(15.1%).

Chi – square/Logistic Regression

Table 6: Shows the chi – square distribution of respondent on commonness of the diphtheria

Crosstab					
Count					
		How common is Diphtheria in your District?			
		Not common	Common	Very common	Total
Gender	Male	1483	754	818	3055
	Female	725	786	409	1920
Total		2208	1540	1227	4975

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	145.870[a]	2	.070
Likelihood Ratio	143.996	2	.070
Linear-by-Linear Association	5.100	1	.024
N of Valid Cases	4975		

Source: Survey 2022 by Sanusi O. A., Ojo O. D. and Onikola I. O.

H_0: Gender is independent of the commonness of the diphtheria.
H_1: Gender is dependent of the commonness of the diphtheria.

TEST STATISTIC: $X^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$

CRITICAL VALUE $\qquad \alpha = 0.05$

DECISION RULE: Reject H_0 if P-value < critical value (α), if otherwise do not reject.
CONCLUSION: Since P-value (0.070) > Critical value (0.05), do not reject H_0 and therefore conclude that gender is independent of the commonness of the diphtheria.

Table 7: Shows the chi- Square of how Diphtheria is spreading

Crosstab					
Count					
		How does Diphtheria highly spread?			
		Air and Direct contact	Air	Direct contact	Total
Gender	Male	1644	957	454	3055
	Female	944	680	296	1920

Total	2588	1637	750	4975

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.132[a]	2	.053
Likelihood Ratio	11.114	2	.068
Linear-by-Linear Association	5.970	1	.005
N of Valid Cases	4975		

Source: Survey 2022 by Sanusi O. A., Ojo O. D. and Onikola I. O.

H_0: There is no relationship between gender and the spread Diphtheria

H_1: There is relationship between gender and the spread Diphtheria.

TEST STATISTIC: $X^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$

CRITICAL VALUE $\alpha = 0.05$

DECISION RULE: Reject H_0 if P-value < critical value (α), if otherwise do not reject.

CONCLUSION: Since P-value (0.053) > Critical value (0.05), do not reject H_0 and conclude that there is no relationship between gender and the spread of Diphtheria.

Table 8: Shows the logistic regression showing the variable in the equation

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	How common is Diphtheria in your District?	20.510	2316.806	.000	1	.993	.998
	Have you ever had Diphtheria?	-.066	.111	.359	1	.549	.936
	Did you get to the hospital before it was cured?	.686	.151	20.752	1	.000	.987
	Did you use local herbs to cure it?	-2.661	.132	406.511	1	.000	.070
	Did you notice any symptom(s) before you were diagnosed with Diphtheria?	-1.027	.143	51.711	1	.000	.358
	If you received treatment from the hospital is it free	.179	.205	.761	1	.383	1.196
	Were there any side effects of Diphtheria after treatment?	–2.296	.378	36.958	1	.000	.938
	Do you know how Diphtheria is contacted and transmitted?	1.854	.294	39.739	1	.000	.034
	If yes, how does Diphtheria highly spread?	-.533	.402	1.758	1	.185	.987
	How long does it take to show signs of Diphtheria after being exposed?	-.696	.414	2.829	1	.093	.499
	Is there a treatment for Diphtheria?	3.614	.292	153.659	1	.000	.101
	Do you know that Diphtheria has a vaccine?	-1.133	.151	56.114	1	.000	.322
	Constant	6.857	.882	60.430	1	.000	950.831

Source: Survey 2022 by Sanusi O. A., Ojo O. D. and Onikola I. O.

From table 8 above, the commonness of Diphtheria in Isin is not significant and the result shows that (1- 0.789 = 0.211) about 21% of the respondent claims that the diphtheria is common in Isin local government district while those that claims they have had about Diphtheria is not significant and about (1- 0.936 =0.064) 6.4% of the respondent claims they have had about diphtheria. Also from the analysis, it was discovered that those that get to the hospital before been cure are significant and 98.7% of the respondent that claims they have diphtheria get to the hospital before been cured while the remaining 2.3% claim they use local herbs to cure the diphtheria disease. Also 64.2% of the respondent claims that they notice the symptom(s) before they were diagnosed with Diphtheria. From the analysis 93.8% of the respondent claims there is no side – effects of Diphtheria after treatment and (1- 0.987= 0.013) 1.3% claims that Diphtheria highly spread.

The Logistic model is
X_1 = The commonness of Diphtheria
X_2 = Had about Diphtheria
X_3 = getting to the hospital before it was cured
X_4 = The use of local herbs to cure Diphtheria.
X_5 = Notice of symptom(s) before you were diagnosed with Diphtheria
X_6 = Free treatment from the hospital
X_7 = side – effects of Diphtheria after treatment.
X_8 = How Diphtheria is contacted and transmitted
X_9 = How does Diphtheria highly spread
X_{10} = How long it take to show signs of Diphtheria after being exposed.
X_{11} = Treatment for Diphtheria.
X_{12} = Diphtheria has a vaccine.
The logistic equation is
$LOGY = 6.857+0.510X_1 - 0.066X_2 + 0.686X_3 - 2.661X_4 - 1.027X_5 + 0.179X_6 + 2.296X_7 + 1.854X_8 - 0.533X_9 - 0.696X_{10} + 3.614X_{11} - 1.133X_{12}$
After the test of significant the model reduced to
$LOGY = 6.857 + 0.686X_3 - 2.661X_4 - 1.027X_5 + 2.296X_7 + 1.854X_8 + 3.614X_{11} - 1.133X_{12}$

IV.   SUMMARY AND CONCLUSION

This research work was carried out to study the outspread of Diphtheria among the population understudy, to investigate whether the contact and transmission mode depend on gender as well as to fit a logistic model that will provide important theoretical support for disease control decision making. The method that was employed in collecting data is questionnaire method. Five thousand Questionnaires were administered to some selected people from all the political wards of Isin Local Government of Kwara state and 4975 were retrieved for further analysis. The methods of data analysis used were data exploration, Chi-Square test and logistics regression.

Result of the analysis revealed that the gender of respondent indicates that male has the higher frequency of 3055(61.4%) while female has 1920(38.6%). It was also discovered that the level of education of the respondents shows that, Elementary and secondary have the highest level of education with frequency of 3060(61.5%), post-secondary or tertiary with frequency of 1168(23.5%) while post graduate has the lowest frequency of 620(12.5%). From the occupational status of respondents in the study area, it can be observed that students have the highest frequency of 1634(32.8%), followed by government employed with frequency of 1322(26.6%), self-employed have frequency of 1138(22.9%) while retirees have the lowest frequency of 881(17.7%). From the analysis, it was discovered that Diphtheria is not common in the study area of this research and that some people used hospital before getting a cure from the disease while others use local herbs. The widespread of diphtheria in the study area of this research was relatively small and it was discovered that those that suggested Diphtheria as not common has the highest frequency of 2208(44.4%). Also 4000(80.4%) indicated that there is no side effects of Diphtheria after treatment. Moreover, many respondents said Diphtheria is spread through air and direct contact. Results of the Chi – Square analysis shows that there is association between those that have ever had diphtheria according to their district and gender. Also gender is independent of the commonness of diphtheria, gender is independent of the number of days it takes to cure Diphtheria and gender is also independent of symptom(s) the respondent noticed before they have Diphtheria. Also the analysis shows that there is no relationship between gender and the spread of Diphtheria, no relationship between the number of Children and how Diphtheria is been spread and also, no relationship between the level of education and how Diphtheria is spread. Analysis of the logistic regression shows that commonness of Diphtheria is not significant. Also from the analysis, it was discovered that those that get to the hospital before been cured are significant and 98.7% of the respondent that claims they have diphtheria get to the hospital before been cured while the remaining 1.3% claim they use local herbs to cure the disease. The logistic regression is given as
$\log Y = 6.857+0.510X_1 - 0.066X_2 + 0.686X_3 - 2.661X_4 - 1.027X_5 + 0.179X_6 + 2.296X_7 + 1.854X_8 - 0.533X_9 - 0.696X_{10} + 3.614X_{11} -$

$1.133X_{12}$ and after the test of significant, the model the model was reduced to

$Log\ Y = 6.857 + 0.686X_3 - 2.661X_4 - 1.027X_5 + 2.296X_7 + 1.854X_8 + 3.614X_{11} - 1.133X_{12}.$

Recommendation

1. Health Planner should educate people more on the danger of Diphtheria and the preventive measures.

2. Health Planner should administer enough drugs to Diphtheria patients on appropriate basis.

3. Government at federal, states and local government should encourage a collective fight against Diphtheria.

4. Government at federal, states, and local government should embark on a massive enlightenments and awareness at rural areas were most of the population resides.

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