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Estimation of Hypertension Prevalence among Diabetic Patients with Respect to Certain Covariates

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Abstract

This study investigates the risk factors associated with the prevalence of hypertension among diabetic patients in Jalingo, Taraba State, Nigeria, using logistic regression analysis. The results indicate a significantly high prevalence rate of hypertension among diabetic individuals, estimated at approximately 89.8%, with a 95% confidence interval ranging from 86.3% to 93.3%. The odds of a diabetic patient developing hypertension are about 8.8 times higher than not developing it. Logistic regression analysis identified systolic blood pressure and a family history of diabetes as significant predictors of hypertension. Specifically, a one-unit increase in systolic blood pressure corresponds to a 9.14% increase in the odds of being hypertensive, with the 95% confidence interval for the true odds ratio ranging from 5.59% to 12.82%. Additionally, diabetic patients with a family history of diabetes exhibit a 296.81% higher likelihood of developing hypertension compared to those without such a history, with the confidence interval for this odds ratio spanning from 7.65% to 1362.73%. These findings highlight the importance of monitoring systolic blood pressure and family history as key covariates in predicting hypertension risk among diabetic populations. Overall, the binary

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logistic regression model demonstrates robust predictive power for identifying hypertensive risk among diabetic patients based on these factors.

Keywords: Hypertension; Diabetes Mellitus; Prevalence Rate; Logistic Regression; Risk Factors; Odds Ratio

INTRODUCTION

Hypertension and diabetes mellitus are two of the most prevalent non-communicable diseases globally, often coexisting and synergistically contributing to increased morbidity and mortality (Sethi et al., 2023 and Hezam et al., 2024). The coexistence of these conditions significantly elevates the risk of cardiovascular complications, renal failure, and premature death (Usman et al., 2021 and Palsson and Patel, 2015). Among individuals with diabetes, hypertension is not only more common but also develops earlier and with greater severity compared to the general population, underscoring the importance of early identification and management of modifiable risk factors (Naha et al., 2021; and Lithovius and Groop, 2023).

Understanding the determinants of hypertension in diabetic populations is crucial for guiding targeted interventions and improving patient outcomes. Several demographic, behavioral, and clinical variables have been implicated in the development of hypertension among diabetic patients, including age, sex, body mass index (BMI), duration of diabetes, glycemic control, physical inactivity, and comorbid conditions (Negussie and Abebe, 2025; Mwimo et al., 2023; and Babandina, 2029). However, the strength and significance of these associations can vary across different populations and healthcare settings.

Logistic regression analysis provides a robust statistical framework for examining the relationship between multiple risk factors and the binary outcome of hypertension. This method is particularly valuable in medical research for identifying independent predictors and quantifying their effects while controlling for potential confounder (Iddrisu et al., 2023; Ahmad et al., 2014; Appeli et al., 2024; and Chengkai, 2024).

This study aims to investigate the risk factors associated with hypertension among diabetic patients using logistic regression analysis. By identifying key predictors, the findings may inform clinical practice and public health strategies aimed at integrated management and prevention of complications in this high-risk group.

MATERIALS AND METHODS

The study area of this research is Jalingo. Jalingo is the capital of Taraba State located in the northeastern region of Nigeria. Its population is 220,700 in an area of 401.2 kilometer, with a population density of 550.1 kilometer square (CP, 2022).

In this research study, secondary data is collected from Federal Medical Centre (FMC), Jalingo Taraba State. The data collected focused on diabetic patients who are hypertensive and those who are not hypertensive receiving treatment at the FMC. The variables on which data is collected from each of the 294 diabetic patients reported in the FMC are age (continuous variable), sex (categorical variable), education level (categorical variable), body mass index (BMI) (continuous variable), systolic blood pressure (SBP) (continuous variable), fasting blood sugar (FBS) (continuous variable), family history of hypertension (FHH) (categorical variable), family history of diabetes (FMB) (categorical variable), and hypertension status (present or absent). The data collected is cross-sectional.

In this study, two statistical methods are employed. The first method is employed to determine the prevalence rate of hypertension among diabetic patients in FMC Jalingo. Estimation of the prevalent rate, non-prevalent rate, its odds and confidence intervals were obtained. Significance test using Z test statistic is employed to determine the significance of the prevalence rate of hypertension was employed. The second method employed is binary logistic regression model which was fitted to the data to predict the prevalence of hypertension given set of covariates. Deviance adjusted R-square and Akaike Information Criterion (AIC) of the binary logistic regression model were employed to determine a better model that fits the data. Deviance, Pearson and Hosmer-Lemeshow were used to assess the goodness of fit of the model to the data. Multicollinearity diagnostic test using variance inflation factor (VIF) was used to find the existence of the problem of collinearity among the set of covariates. Odds ratios were used to interpret the relationship of the significant covariate with the prevalence of hypertension among the diabetic patients.

For this research, the binary logistic regression model to be fitted is given as:

$$P(Event) = \frac{exp(Y')}{1+exp(Y')}$$

$$Y' = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p \ .$$

The log odds of the probability of the event is given as:

$$log\left(\frac{P(Event)}{P(Non-Event)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p$$

where,

$P(Event)$ is the probability the outcome of interest (in this study, it is having hypertension),

$X_1, X_2, \ldots, X_k$ are the predictor variable (or covariates),

$\beta_0, \beta_1, \beta_2, \ldots, \beta_p$ are coefficients to estimate.

Assumptions of the model:

(1) Binary assumptions (only two possible outcomes on the dependent variable).

(2) Independence of observations.

(3) Linearity of log odds and predictors (not the outcome itself).

(4) No multicollinearity among the predictors.

RESULTS

Prevalence of Hypertension among Diabetic Patients

To determine the prevalence of hypertension among the diabetic patients, Table 1 below shows the number of diabetic patients, those who are hypertensive, the prevalence rate odds of hypertension among the diabetic patients. The estimated prevalence rate of hypertension among the diabetic patients is 0.89796, while the non-hypertensive is 0.102041. The estimated odd of the prevalence is 8.799982. The odds of a diabetic patients having hypertension is 8.799982 times higher than not having it.

Table 1: Descriptive Statistics of Hypertension Prevalence

Sample Size	Hypertension Cases	Prevalence Rate	Non-Prevalence Rate	Odds
294	264	0.897959	0.102041	8.799982

Table 2 shows the standard error of the prevalence rate of hypertension among the diabetic patient, the 95 percent confidence interval of the true prevalence rate, the z statistic value testing the null hypothesis (H_0) that the prevalence rate is 0.5, and the three alternative hypotheses.

Table 2: Z-Test Results

Standard Error	Z statistic value	95% Conf. Interval		$H_1: p < 0.5$	$H_1: p = 0.5$	$H_1: p > 0.5$
		Lower	Upper	Sig.		
0.017654	13.6472	0.863358	0.932560	1.0000	0.0000	0.0000

The standard error of the estimated prevalence rate is small indicating that the estimator of the prevalence rate is reliable for the observations. The true prevalence rate of hypertension in the population of diabetic patients can be said, with 95 percent confidence that it lies within 0.863358 and 0.932560. Expressing this in percentage, the true prevalence rate of hypertension among diabetic patients lies between about 86.3% and 93.3%. Diabetic patients are highly likely to be hypertensive. Testing for the significance, the Z test statistic value is 13.6472, which is not small. The corresponding p-value for left tailed test (= 1.0000) shows that the null hypothesis should not be rejected. Since this alternative hypothesis is saying that the prevalence rate is less than 50% of the diabetic patients, and the fact is saying the prevalence rate is more than 50%, then the null hypothesis is preferred. The corresponding p-value for two-tailed test (= 0.0000) informs that the null hypothesis should be rejected. This means the prevalence rate of hypertension among the diabetic patients is not 50%. The corresponding p-value for right-tailed test (= 0.0000) shows more specifically, that the null hypothesis should be rejected, while the alternative saying that the prevalence rate is significantly greater than 50% is to be sustained.

Effect of Risk Factors on the Prevalence of Hypertension among Diabetic Patients

Age of patients, sex of patients, educational level of patients, family history of hypertension of patients, family history of diabetics, body mass index of patients, systolic blood pressure of patients and fasting blood sugar level of patients are considered as the risk factors associated with hypertension diabetic patients. Binary logistic regression technique is employed to determine the effects of the risk factors. The link function is logit and the model event is a diabetic patient being hypertensive.

The estimated logistic regression equation is given as:

$$P(Event) = \frac{exp(Y')}{1+exp(Y')}$$

$$Y' = -9.60 - 0.0101Age + 0.0621BMI + 0.0938SBP - 0.00141FBS + 0.Male - 0.033Female + 0.No\ Edu - 1.172Primary\ Edu - 0.659Secondary\ Edu - 0.619Tertiary\ Edu + 0.Absence\ of\ Hypertension\ in\ family + 0.658Presence\ of\ Hypertension\ in\ family + 0.Absence\ of\ Diabetics\ in\ family + 1.538Presence\ of\ Diabetics\ in\ family.$$

Table 4 shows the coefficients, standard coefficients, Z statistic value, corresponding p-value, and variance inflation factor of each risk factor associated with the event hypertension.

Table 4: Coefficients of the Risk Factors

Term	Coef	SE Coef	Z-Value	P-Value	VIF
Constant	-9.60	3.01	-3.19	0.001	
Age	-0.0101	0.0172	-0.59	0.558	1.09
BMI	0.0621	0.0383	1.62	0.105	1.09
SBP	0.0938	0.0182	5.15	0.000	1.10
FBS	-0.00141	0.00696	-0.20	0.840	1.07
Sex					
Female	-0.033	0.485	-0.07	0.946	1.11
Education					
Primary	-1.172	0.918	-1.28	0.202	3.62
Secondary	-0.659	0.905	-0.73	0.466	3.68
Tertiary	-0.619	0.980	-0.63	0.528	2.79
Family History of Hypertension					
Presence of hypertension	0.658	0.640	1.03	0.303	1.10
Family History of Diabetics					
Presence of diabetics	1.538	0.686	2.24	0.025	1.04

The p-values for the constant term, systolic blood pressure and presence of diabetics in the family are respectively, 0.001, 0.000 and 0.025, which are each less than 5% level of significance. The constant term, systolic blood pressure and presence of diabetics in the family are significant in the logistic regression equation. The p-values of all the other variables are largely higher than 5% level of significance, clearly indicating that they are not significance in the logistic regression equation.

The variance inflation factor value for each risk factor is less than 5, indicating there is no problem of multicollinearity.

Since only systolic blood pressure and presence of diabetics in the family are the two predictors that are significant, logistic regression equation for the two predictors only is fitted and the results are displayed below.

The estimated logistic regression equation is:

$$P(Event) = \frac{exp(Y')}{1+exp(Y')}$$

$$Y' = -8.18 + 0.0875 Systolic\ Blood\ Pressure - 0.\text{Absence of diabetics in the family} + 1.378\text{Presence of diabetics in the family}$$

Table 5 below shows the coefficients, standard coefficients, Z statistic value, corresponding p-value, and variance inflation factor for the predictors.

Table 5: Coefficients of the Predictors

Term	Coef	SE Coef	Z-Value	P-Value	VIF
Constant	-8.18	1.80	-4.55	0.000	
Systolic Blood Pressure	0.0875	0.0169	5.18	0.000	1.00
Family History of Diabetics					
Presence of Diabetics	1.378	0.666	2.07	0.038	1.00

The p-values of the constant term, systolic blood pressure and presence of diabetics in the family are each less than 5% level of significance. Systolic blood pressure and presence of diabetics in the family are significant predictors to a diabetic patient being hypertensive.

Table 6 below shows the odds ratios and 95 percent confidence interval for systolic blood pressure being the continuous predictor.

Table 6: Odds Ratios for Continuous Predictors

	Odds Ratio	95% CI
Systolic Blood Pressure	1.0914	(1.0559, 1.1282)

The odds ratio of systolic blood pressure is 1.0914. A diabetic patient with a unit higher systolic blood pressure value has a 9.14 percent increase in the odds of being hypertensive. We are 95 percent confident that the true odds ratio for a diabetic patient with systolic blood pressure, having hypertension, lies within 1.0559 and 1.1282.

Table 7 shows the odds ratios and 95 percent confidence interval for presence of diabetics in the family being the categorical predictor.

Table 7: Odds Ratios for Categorical Predictors

Level A	Level B	Odds Ratio	95% CI
Family History of Diabetics			
Presence of diabetics	Absence of diabetics	3.9681	(1.0765, 14.6273)

Odds ratio for level A relative to level B

The odds ratio of presence of diabetics in the family is 3.9681. A diabetic patient with history of diabetics in the family has 3.9681 times higher odds of being hypertensive than a diabetic patient with no history of diabetics in the family. We are 95 percent confident that the true odds ratio for a diabetic patient who has diabetics in the family compared to a diabetic patient who has no diabetics in the family, having hypertension, lies within 1.0559 and 1.1282.

Two regression equations have been considered, the first contains all the risk factors in the study, and the second contains only two closely associated risk factors. Table 8 shows the deviance coefficient of determination, deviance adjusted coefficient of determination and Akaike information criterion for the first and second models (regression equations).

Table 8: Model Summary

Model	Deviance R-square	Deviance R-square (adj)	AIC
First	36.13%	30.97%	145.77
Second	32.88%	31.85%	136.06

The deviance adjusted coefficient of determination for the first model is less than that of the second model. The predictors contained in the second model contribute a higher variation than the predictors in the first model. The Akaike information criterion value in the first model is higher than that of the second model. This indicates that the second model performs better than the first model. By the deviance adjusted coefficient and the Akaike information criterion, the second model is better in predicting a non-diabetic patient being hypertensive.

Table 9 shows three goodness-of-fit tests which are Deviance, Pearson and Hosmer Lemeshow for the second model.

Table 9: Goodness-of-Fit Tests

Test	DF	Chi-Square	P-Value
Deviance	291	130.06	1.000
Pearson	291	138.14	1.000
Hosmer-Lemeshow	8	10.30	0.245

Each of the goodness of fit test has a p-value greater 5% level of significance. This indicates that binary logistic regression model fits the data very well.

DISSCUSSION

In this study, the prevalence rate of hypertension among the diabetic patients is significantly greater than 50%. The estimated prevalence rate is about 89.8% and the true prevalence rate lies within about 86.3% and 93.3%. The odd of a diabetic patient having hypertension is about 8.8 times higher than not having hypertension.

Two binary logistic regression models were compared. The first model considered all the risk factors in the study, while the second model considered only the significant risk factors associated with hypertension among the diabetic patients. Using deviance adjusted coefficient of determination, the second model has a higher value of 31. 85%, while the first model has a lower value of 30.97%. So, the second model is better than the first model in predicting hypertension among diabetic patients. Using AIC criterion in determining the better model, the second model has a lower AIC value of 136.06, while the first model has a higher AIC value of 145.77. The second model is better in modeling prevalence of hypertension among the diabetic patients. So, from the second model, the significant predictors associated with hypertension are systolic blood pressure and family history of diabetics. The odds ratio for systolic blood pressure is 1.0914, meaning that a unit higher systolic blood pressure has a 9.14% increase in the odd of being hypertensive. The 95% confidence interval of the true odds ratio lies within 1.0559 and 1.1282. The odds ratio of presence of diabetic in the family is 3.9681, meaning that a diabetic patient with presence of diabetic in the family has 3.9681 times higher odd of being hypertensive than a diabetic patient with absence of diabetic in the family. The 95% confidence interval that the true odds ratio for a diabetic patient who has diabetic in the family compared to the diabetic patient who has no diabetic in the family, having hypertension lies within 1.0765 and 14.6273. Deviance test, Pearson test, and Hosmer Lemeshow test for goodness of fit showed that the logistic regression model fits the data is good. Generally, binary logistic regression models demonstrated strong predictive capabilities for identifying hypertensive patients based on the selected risk factors. We recommend that logistic regression can be used to determine the risk factor associated with hypertension. Systolic blood pressure and

family history of diabetics should always be considered as a risk factor that determines the outcome of hypertension both in diabetic patients.

CONCLUSION

This study identifies key risk factors associated with hypertension prevalence among diabetic patients in Jalingo, Taraba State, Nigeria, through logistic regression analysis. The prevalence of hypertension in this population is notably high at approximately 89.8% (95% CI: 86.3%–93.3%), with diabetic patients exhibiting an 8.8-fold greater odds of developing hypertension compared to not having it. Among the risk factors examined, systolic blood pressure and family history of diabetes emerged as significant predictors. Specifically, each one-unit increase in systolic blood pressure corresponds to a 9.14% increase in the odds of hypertension (OR = 1.0914; 95% CI: 1.0559–1.1282), while the presence of diabetes in the family increases the odds nearly fourfold (OR = 3.9681; 95% CI: 1.0765–14.6273).

Model comparison favored the parsimonious model including only these significant predictors, which demonstrated superior fit based on a higher deviance-adjusted coefficient of determination (31.85% vs. 30.97%) and a lower Akaike Information Criterion (AIC = 136.06 vs. 145.77). Goodness-of-fit tests, including deviance, Pearson, and Hosmer–Lemeshow, confirmed the model's adequacy. Collectively, these results affirm the robust predictive capability of logistic regression in identifying hypertension risk among diabetic patients based on systolic blood pressure and family history.

This research contributes to epidemiological understanding by quantifying the elevated hypertension risk within diabetic populations and emphasizing key modifiable and non-modifiable predictors. Practically, it underscores the necessity of vigilant monitoring and management of systolic blood pressure alongside consideration of family medical history in clinical assessment and intervention planning for diabetic patients.

Future studies should aim to expand sample diversity and incorporate additional biological and lifestyle variables to further elucidate hypertension determinants. Longitudinal analyses may also enhance causal inference and inform targeted preventive strategies in similar populations.

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