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LOG LINEAR MODELLING OF THE CASES OF DIABETES MELLITUS AND HIGH BLOOD PRESSURE ON GENDER IN NIGERIA

[1]ZEBULUN, Gladys ThankGod, ;[2]OKORO, Joyce Adaobi & [3]BIU, O. Emmanuel

[1]Department of Mathematics and Statistics, Ignatius Ajuru University of Education, Rivers State
[2,]Department of Mathematics, Federal College of education (Technical), Omoku, Rivers state
[3]Department of Mathematics and Statistics, University of Port Harcourt, Rivers state ,Nigeria.
Corresponding Email :**joyce.adaobi @fcetomoku.edu.ng**

Abstract
This research examined cases of Diabetes mellitus (DM) and High blood pressure (HBP) on gender (Sex), using descriptive statistics, trend components, 2-Way Log Linear Model (2×2) and 3-Way Log Linear Model (2×2×2). The results revealed that as the year's goes, the cases of DM and HBP increases, where DM cases are more in female than male and HBP cases are more in male than female. Furthermore, the trend components analysis (i.e. Linear and Quadratic) done for male and female over the years (1985-2019) with respect to the cases of DM and HBP. It was observed that the quadratic trend curve best fits the data sets, these results was confirmed by the values of R-square and accuracy measures. The DM cases R-square values for male and female are 99.88% and 99.92%, while HBP cases R-square values are 99.99% and 99.96%. The quadratic trend accuracy measures are smaller than the linear trend in both male and female cases in term of DM and HBP. The 2-Way Log Linear Model (2×2) odds ratio was 0.914 and P(odds ratio) = 1 – 0.914 = 0.086 indicated that male having diabetes are 8.6% less likely to have HBP than female. The Pearson chi square X^2 = 119749.712 (large value) and p-value = 0.000 <∝= 0.05, showed that the independence model fits the data in ascertain whether or not HBP is related with DM cases HBP in term of gender. Hence, the null hypothesis was accepted indicating that there is no relationship between the numbers of cases with DM & HBP in term of gender. The fact that males with DM are at high risk of having HBP does not suggest that females will also have. In addition, the 3-Way Log Linear Model (2×2×2) p-value is 0.005 which is significant at 5%, and its R-Square value of 90.68% explains that this model also fits the data sets fairly well. From this results, it is observed that gender show no association in the number of cases with DM and HBP, while there is association in term of the number cases below and above the average DM and HBP cases. The 3-Way Log Linear Model (2×2×2) result is similar to the 2-Way Log Linear Model (2×2) above. It is therefore recommended that a study on forecasting the cases of DM and HBP be carried out in subsequent researches.

Keywords: *Diabetes mellitus (DM); descriptive statistics, High blood pressure (HBP);trend components; 2-Way Log Linear Model (2×2); 3-Way Log Linear Model (2×2×2); R-square and Accuracy Measures.*

Introduction

Diabetes mellitus (DM) is a frequent and increasing public health problem by itself. 422 million people have diabetes worldwide and over 1.2 billion have high blood pressure (HBP). The occurrence in most Western countries varies between 2 to 5% and it is quickly increasing in African countries due to changes in eating habits during the most recent years (Beatrice et al, 2018). The association between DM and HBP has been described in 60 to 65% of diabetics' research (Contreras, 2000, Aswin et al., 2022; Yang et al., 2017). High

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blood pressure, insulin resistance are found mainly in skeletal muscle involving the transformation of glucose to glycogen independently of blood flow. The degree of resistance is related to the severity of high blood pressure and differs between races. States of insulin-resistance and hyperinsulinaemia have been postulated as causes and/or consequences of high blood pressure. Irrespective of the category of DM, high blood pressure is two to three times public among diabetics compared with non-diabetics.
It is also known that HBP is two to three times more frequent in diabetic patients. These patholnies (DM and HBP), when they coexist there is an increase of two to eight times in morbidity for cardiovascular disease which are independent risk factors for cardiovascular disease and the mortality for those diseases is replicated. This research seeks to use log linear model to analyze and ascertain the relationship between DM and HBP on gender.
The aim of this study is to ascertain the relationship between diabetes mellitus and high blood pressure in term of gender using log linear analysis. The objectives are to:
1) Estimate the descriptive statistics of male and female with DM and high HBP cases over the years
2) Examine the trend components for the number of male and female with diabetes and with high blood pressure.
3) Ascertain whether or not high blood pressure is related with diabetes mellitus on gender basis

Definition of terms
Trend: is used to describe if the data is showing an appreciating or depreciating movement for all of or part, the time series.
Contingency Table: is a table used in statistics to summarize the relationship between several categorical variables.
Hyperinsulinaemia: is a condition in which there are excess levels of insulin circulating in the blood relative to the level of glucose.
Overparameterization: it imply that the number of parameters (coefficients) is more than what can be uniquely estimated.
NCD-RisC:Non – Communicable Disease Risk Factor Collaboration
NIDDK – National Institute of Diabetes and Digestive and Kidney Disease

Review of Literature
Diabetes is a disease that occurs when an individual blood glucose (or blood sugar) is too high. Blood glucose (BG) is the main source of energy of an individual which comes from the food the individual eat. Insulin made by the pancreas hormone, helps glucose from food get into person cells to be used for energy (NIDDK, 2016). Sometimes human body doesn’t make enough of any insulin or doesn’t use its well. Then, glucose continue to be in a particular place in the person blood and doesn’t reach person cells.Health problems can be cause by having too much glucose in your blood over time. Even though diabetes has no cure, an individual stay healthy and take steps to manage the DM disease. Occasionally, people call DM “a touch of sugar” or “borderline diabetes”. These terms suggest that someone doesn’t actually have diabetes or has a minus serious case, but every case of diabetes is serious illness.
The common types of DM cases are type 1, type 2, and gestational diabetes.
Type 1 diabetes: This DM cases does not make insulin in the person body and the person immune system is attacks and destroys the cells that make insulin in the person pancreas. Type 1 diabetes is usually detected in young adults and children, although it can appear at any age. People with type 1 diabetes need to take insulin every day to stay healthy and alive (NIDDK, 2016).
Type 2 diabetes: Similarly, this DM cases does not make or use insulin well in the body and its can develop at any age, even during childhood. Nevertheless, this type of DM occurs most often in middle-aged and older people. Type 2 is the most common type of DM cases (NIDDK, 2016).

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Gestational diabetes: This DM cases is develops in some women when they are pregnant. Most of the time, this type of DM goes away after the baby is born. However, if pregnant women had gestational diabetes, they have a greater chance of developing type 2 diabetes later in life. Sometimes diabetes detected/diagnosed during pregnancy is really type 2 diabetes.

Blood pressure: Blood pressure is the dynamic of the blood pushing against the artery walls. Every single time the heart beats, it is moving blood into these arteries, resulting in the highest blood pressure when the heart contracts and is pumping the blood in the body up and down (or pushing the blood through the body). HBP, or hypertension, directly increases the risk of heart attack) coronary heart disease and brain attack (stroke). According to MedlinePlus (2020) person with HBP, the arteries may have an increased resistance against the movement of blood, causing the heart to pump harder to circulate the blood. Two numbers are used to measure blood pressure. There are the **systolic pressure** (number on the top) and **diastolic pressure (**number on the bottom**)**. The systolic pressure (SP) refers to the pressure inside the artery when the heart contracts and is pumping the blood through the body, while the diastolic pressure (DP) refers to the pressure inside the artery when the heart is at rest and is filling with blood. The systolic and diastolic pressures are both documented by means of "mm Hg" (millimeters of mercury).According to the National Heart, Lung, and Blood Institute of the National Institutes of Health (NHLBI, 2003),

a) HBP for adults is defined as: 140 mm Hg or greater SP and 90 mm Hg or greater DP.
b) NHLBI recommendations for prehypertension are: 120 mm Hg – 139 mm Hg SP and 80 mm Hg – 89 mm Hg DP.
c) NHLBI recommendations define normal blood pressure as follows: Less than 120 mm Hg SP and Less than 80 mm Hg DP

HBP is a particularly common co-morbidity of diabetes, affecting 20–60% of individuals with diabetes. The frequency occurrence of high blood pressure in the diabetic population is 1.5 to 3 times higher than that of non-diabetic age-matched groups. Many individuals/patients with diabetes have high blood pressure at the time of diagnosis, while others develop it as the duration of the disease lengthens. About 60% of Nigerian diabetics have high blood pressure such as it is found in many other areas of the world. Females seem to have a slightly higher incidence of concomitant type 2 diabetes and high blood pressure. Up to 80% of patients with type 2 diabetes will develop or perish of the macro-vascular disease (Aswin et al., 2022).

In the study of Ayodeji et al., *(*2007) "Control of hypertension in Nigerians with DM: A report of the Ibadan diabetic/kidney disease study group", where a total of 256 patients with diabetes, aged range of 21 to 83 years (mean 59.1±12.8 years) attending the Diabetes Clinic of the University College Hospital, Ibadan, Oyo state, Nigeria were involved. 57% had co-existing hypertension and 15.5% of these patients were not receiving any antihypertensive agent. There results showed a significantly higher systolic BP among females compared to males ($p < 0.05$). Diabetic patients with hypertension were significantly older than those with diabetes alone ($p < 0.001$). Sixty-Six percent of patients with both diabetes and hypertension compared to 48% in those with diabetes alone ($p<0.005$), when the body mass index (BMI) was higher than 25. An acceptable mean systolic (<130 mmHg) and diastolic BP (<80 mmHg) BP was achieved in only 38.5% and 42.2% of all patients respectively. The association between body mass index and blood pressure was found to be significant only for the DP ($p <0.05$). Only 52% of the patients with hypertension were receiving angiotensin converting enzyme inhibitors as part of their cure (or medication). Beatrice et al ., (2018) researched on "the prevalence and correlates of hypertension and DM in an urban community in North Western Nigeria". Adults aged between 18 years and above, who attended a medical outreach program were screened and interviewed for hypertension and DM. The primary data outcomes were analyzed using STATA version 14 and presented as mean±standard deviation and frequencies. Then, Chi-square and Pearson's correlation co-efficient were used to identify the correlates of hypertension and diabetes mellitus, at 5% level of significance. The mean age of respondents was 51.0 ± 14.0 years and 87.8% were females. Prevalence of hypertension and DM were 55.9% and 23.3% respectively. Age greater than 40 years and female gender were associated with risk of hypertension and DM respectively, $p < 0.05$. There was a weak correlation between systolic hypertension and age ($r = 0.18$,

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p = 0.02), diastolic hypertension and BMI (r = 0.16, p = 0.03) and blood sugar and waist circumference (r = 0.19, p = 0.02). They concluded that there is need for the implementation and development of a community-based public health interventions aimed at dropping their risk factors because of the high prevalence of hypertension and DM among the study population.

Log-linear model is used in the analysis of contingency tables which is a form of generalized linear model for counted data, where the variety of associations and interaction terms can easily be explained by the goodness of fit tests. It is a multidimensional extension of the classical cross-tabulation called chi-square test. Log-Linear Models can determine complex interactions in multidimensional contingency tables with more than two categorical variables while the Chi-square test can extremely consider only two variables at a time (Allen, 2017). Certainly, Log-Linear Models combine characteristics of cross-tabulation such as chi-square tests (i.e. determining the fit between expected and observed cell counts) with those of analysis of variance (i.e. ANOVA; simultaneous testing of main effects and interactions within multifactorial designs), which is why Log-Linear Models are sometimes informally referred to as ANOVA for categorical data. Log-Linear Models make use of the likelihood ratio chi-square statistic instead of the Pearson chi-square statistic, which is calculated differently, but has approximately the same distribution when numbers of observations are large. The log-linear models have two advantages, it's that they are flexible and interpretable. Log-linear models have all the flexibility associated with ANOVA and regression (Agresti, 2002; Masahiro 2007). Oluwole et al., (2019) studied "Log-linear modelling of effect of age and gender on the spread of hepatitis B virus infection in Lagos state. They used a ten years data sets from a period of 2006 to 2015, collected from Nigeria Institute of Medical Research (NIMR). A log-linear modelling approach was engaged with the help of R-programming language software. Akaike Information Criterion (AIC) method of model selection was used in selecting the best model. Selecting the best model among several log-linear models developed, model: Age & Year (AY): Gender & Years (GY) was identified to be the best model since its AIC value (117.37) is the lowest and the highest using likelihood ratio test (235.63583). It was also discovered from the analysis that both factors (age and gender) have a significant effect on the spread of hepatitis B infection, this implied that the age at which an individual is tested positive to hepatitis B virus will affect the spread of the disease. In selecting the best model among the four models that were developed, model AY: GY (Age & Year: Gender & Year) was found to be the best model.

Methodology

Data and Method

This study was limited to the average number of **515,967,749** adults with DM and HBP cases in Nigeria covering the period of 1985–2019. The data was collected from NCD-RisC (a network of health scientists around the world that provides rigorous and timely data on major risk factors for non-communicable diseases for all of the world's countries), the data consist of total number of males and Females with DM and HBP from 1985-2019. The descriptive statistics of adults with DM and HBP was determined using SPSS, the comparison of their trend components were analyzed using MS-Excel & Minitab and log linear model was used to ascertain how diabetes is related with high blood pressure.

Model Specifications

Suppose that we collect data on two binary variables, A and B for *n* sample units. Let n_{ij} be the number of subjects having the following characteristics *(A=i, B=j)* (that is, the number of subjects falling into a particular cell of the two-way table, more specifically falling into the *ith* level of A and the *jth* level of B). The total sample size is $\sum_{i=1}^{I} n_{ij} \sum_{j=i}^{J} n_{ij} = n$. The levels of the first variable are represented by the index *i* and the levels of the second variable by index *j*. The counts may be arranged in a 2×2 table:

A, taking possible values $i=1, \ldots, I \quad where\ I = 2$

B, taking possible values $j=1, \ldots, J \quad where\ J = 2$

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The data then consists of n pairs
$(A_1, B_2), (A_2, B_2), \ldots, (A_n, B_n)$
Which can be summarized in a frequency table

	B=1	B=2
A=1	n_{11}	n_{12}
A=2	n_{21}	n_{22}

The total number of cells in the table is denoted as $n = IJ$, which is 4 in this case
The row totals are

$$n_{1.} = n_{11} + n_{12}$$

$$n_{2.} = n_{21} + n_{22}$$

The column totals are

$$n_{.1} = n_{11} + n_{21}$$

$$n_{.2} = n_{12} + n_{22}$$

The grand total is $n_{..} = n_{11} + n_{12} + n_{21} + n_{22} = n$ (3.1)

The table is given as

	B=1	B=2	Total
A=1	n_{11}	n_{12}	$n_{1.}$
A=2	n_{21}	n_{22}	$n_{2.}$
Total	$n_{.1}$	$n_{.2}$	$n_{..}$

Notation extension by any I x J table

	B=1	B=2	$\cdots$	B = J
A=1	n_{11}	n_{12}	$\cdots$	n_{1J}
A=2	n_{21}	n_{22}	$\cdots$	n_{2J}
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
A = I	n_{I1}	n_{I2}	$\cdots$	n_{IJ}

The total number of cells in $n = I$ x J, and the marginal totals are:
$n_{i.} = \sum_{j=1}^{J} n_{ij}, \ i = 1, \ldots, I$ (3.2)
$n_{.j} = \sum_{i=1}^{I} n_{ij}, \ j = 1, \ldots, I$ (3.3)
$n_{..} = \sum_{i=1}^{I} n_{ij} \sum_{j=i}^{J} n_{ij} \ i = 1, \ldots, I$ (3.4)
Let μ_{ij} be the expected counts, E(n_{ij}), in an I x J contingency table, created by two random variables A and B.

Objective
Model the cell counts: $\mu_{ij} = n\pi_{ij}$
Model structure
An analogous saturated log-linear model to two-way ANOVA with interaction is
$\log(\mu_{ij}) = \lambda + \lambda_i^A + \lambda_j^B + \lambda_{ij}^{AB}$ (3.5)
where i=1,…,I and
j=1,…,J are levels of categorical random variables A and B, with constraints:
$\Sigma_i \lambda_i = \Sigma_j \lambda_j = \Sigma_i \Sigma_j \lambda_{ij} = 0$, to deal with overparametrization.
The log-linear model for the independence model is expressed:
$\log(\mu_{ij}) = \lambda + \lambda_i^A + \lambda_j^B$ (3.6)λ represents the "overall" effect, or the grand mean of the logarithms of the expected counts, and it ensures that $\Sigma_i \Sigma_j \mu_{ij} = n$, that is, the expected cell counts under the fitted model add up to the total sample size n.

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- λ_i^Arepresents the "main" effect of variable A, or a deviation from the grand mean, and it ensures that $\Sigma_j \mu_{ij} = n_{i+}$ that is, the marginal totals under the fitted model add up to the observed marginal counts. It represents the effect of classification in row *i.*
- λ_j^B represents the "main" effect of variable B, or a deviation from the grand mean, and it ensures that $\Sigma_i \mu_{ij} = n_{+j}$. This is the effect of classification in column j.
- $\lambda_i^A = \lambda_j^B = 0$, or alternatively,$\Sigma_i \lambda_i^A = \Sigma_j \lambda_j^B = 0$, to deal with over-parametrization

The maximum likelihood (ML) fitted values for the cell counts are the same as the expected (fitted) values under the test of independence in two-way tables, i.e., E $\left(\mu_{ij}\right) = \frac{n_{i+}n_{+j}}{n}$ Thus, the X^2 and G^2 for the test of independence are goodness-of-fit statistics for the log-linear model of independence testing that the independence model holds versus that it does not, or more specifically testing that the independence model is true vs. saturated model is true. This model also implies that ALL odds ratios should be equal to 1.

The Pearson goodness-of-fit statistic is

$$\chi^2 = \sum_{i=1}^{I} \sum_{j=i}^{J} \frac{\left(n_{ij} - \mu_{ij}\right)^2}{\mu_{ij}} \qquad (3.7)$$

In this work, **odds ratio** (OR) is a measure of association between a certain property A (DM Cases) and a second property B (HBP Cases). Specifically, it will tells how the presence/absence of property A (DM Cases) has an effect on the presence or absence of property B (HBP Cases).We can have different parameter estimates (i.e, different values of s) depending on the type of constraints we set. So, what is unique about these parameters that lead to the same inference, regardless of parametrization? The differences, that is the log odds, are unique:

$$\lambda_i^A - \lambda_i^B$$
$$\lambda_j^A - \lambda_j^B$$

where the subscript *i* denotes one level of categorical variable A and "i" denotes another level of the same variable; similarly for B.

Thus the odds is also unique! $\log(odds) = log\left(\frac{\mu_{i1}}{\mu_{i2}}\right) = log(\mu_{i1}) - log(\mu_{i2})$

$$= \left(\lambda + \lambda_i^A + \lambda_1^B\right) - \left(\lambda + \lambda_i^A + \lambda_2^B\right) = \lambda_1^B - \lambda_2^B \qquad (3.8)$$

$$\Rightarrow odds = \exp\left(\lambda_1^B - \lambda_2^B\right) \qquad (3.9)$$

Therefore, the hypothesis below was tested:

H_0: There is no relationship between the numbers of adult with DM & HBP cases in term gender (Independence model $\ln\left(\mu_{ij}\right) = \lambda + \lambda_i^A + \lambda_j^B$holds)

H_1: There is relationship between the numbers of adult with DM & HBP cases in term gender (Saturated model $\ln\left(\mu_{ij}\right) = \lambda + \lambda_i^A + \lambda_j^B + \lambda_{ij}^{AB}$ holds).

Results

Table 1: Descriptive statistics of male and female with diabetes and high blood pressure over the years

Year (1985-2019)	Gender	n	Minimum	Maximum	Mean
Diabetes	Male	35	320395	1956975	939447
	Female	35	416064	1872340	993056
High blood pressure	Male	35	4232344	8171319	6516128
	Female	35	3886264	8347967	6293303

From Table 1, the minimum of male & female with diabetes are 320395 & 416064 and for high blood pressure are 423244 & 3886264 respectively which are figures for the year 1985 and the maximum of male & female

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with high blood pressure are 1956975 & 1872340 and for high blood pressure are 228064483 & 220265628 respectively which are figures for the year 2019; this indicates that cases of diabetes and high blood pressure increases as the year goes by.
The mean of male with diabetes is 939447 and that of female is 993057 indicating that over the year's diabetes are more in female than male.
The mean of male with high blood pressure is 6516128 and that of female is 6293303, this implies that male with high blood pressure are more than female.

Trend analysis plot for male and female with diabetes from 1985 – 2019 using MS-Excel and Minitab

- **Ms-Excel**
- **Minitab**

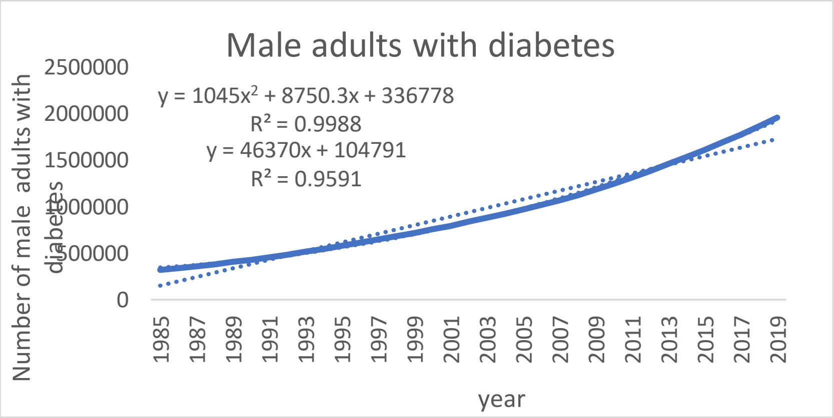

Fig 1

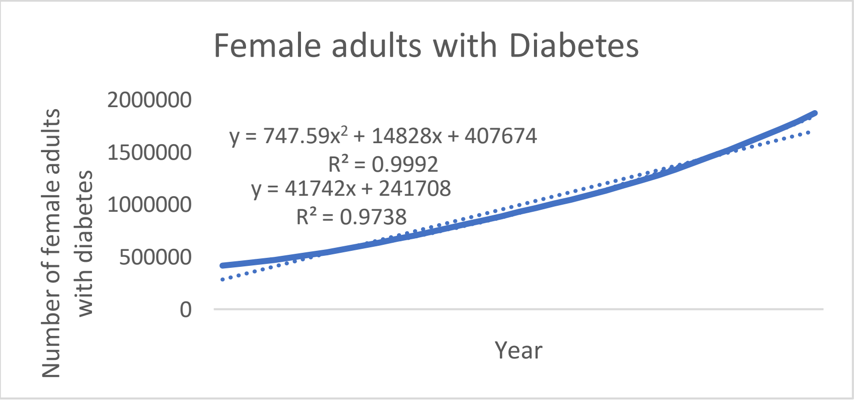

Fig 2

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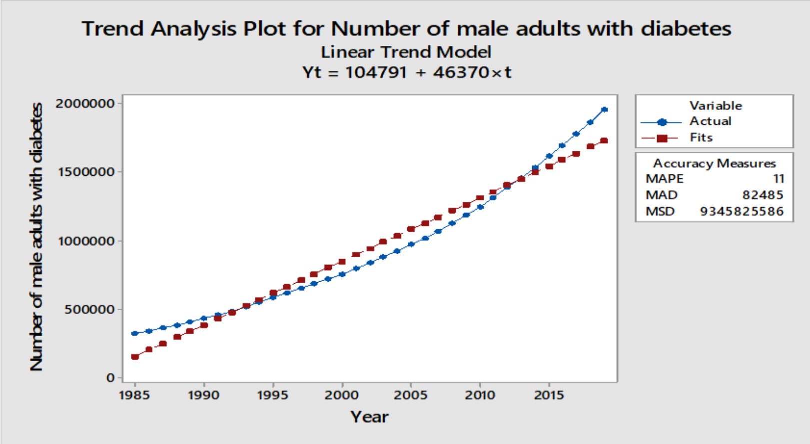

Fig.3

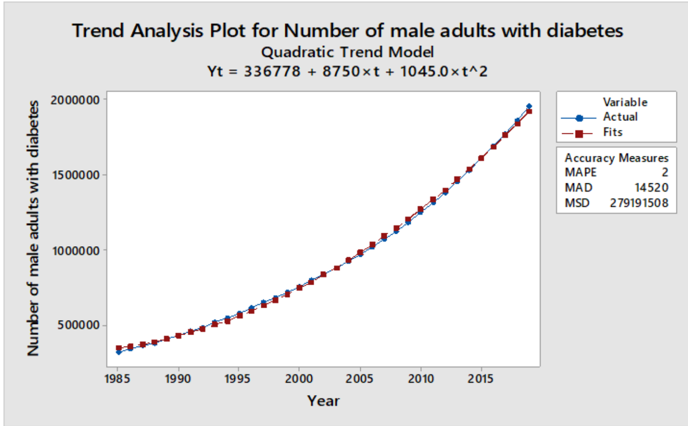

Fig. 4

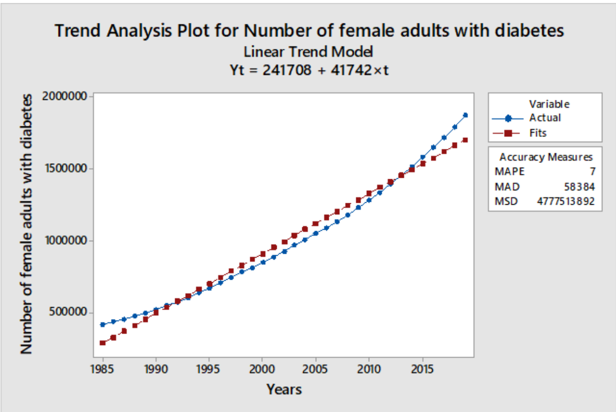

Fig .5

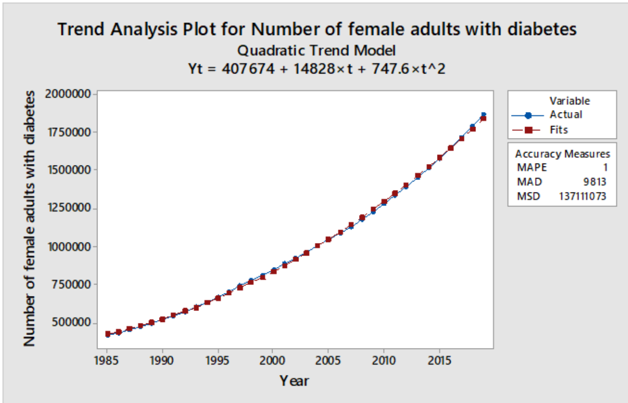

Fig. 6

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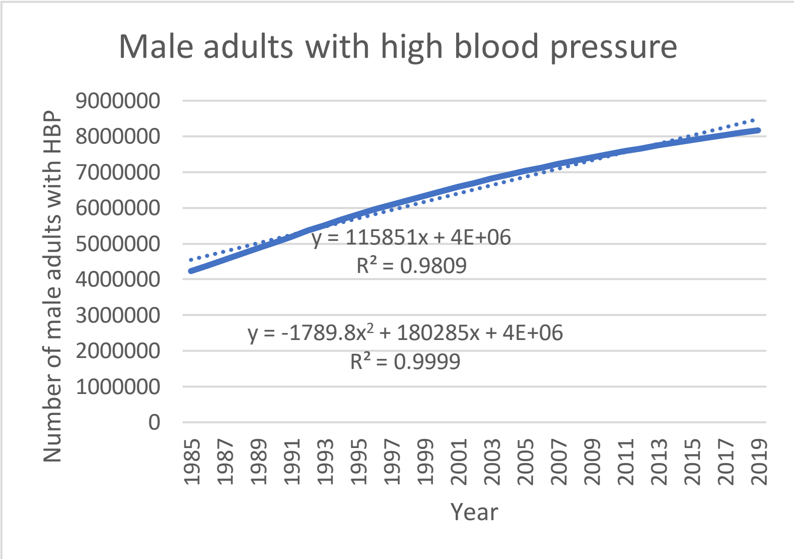

Fig 7

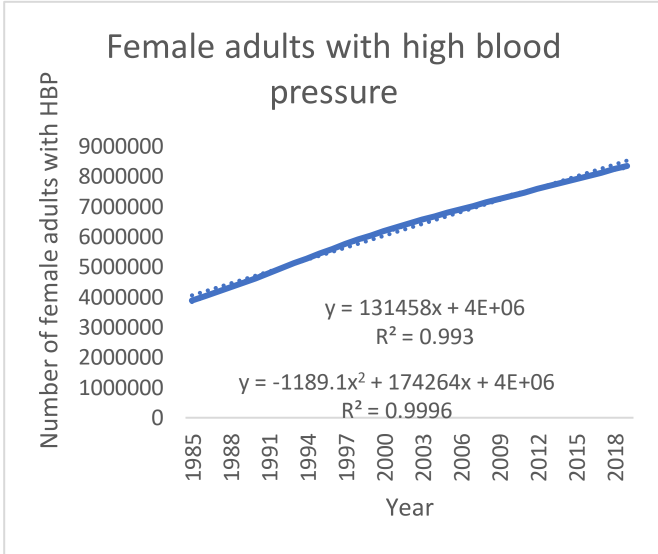

Fig. 8

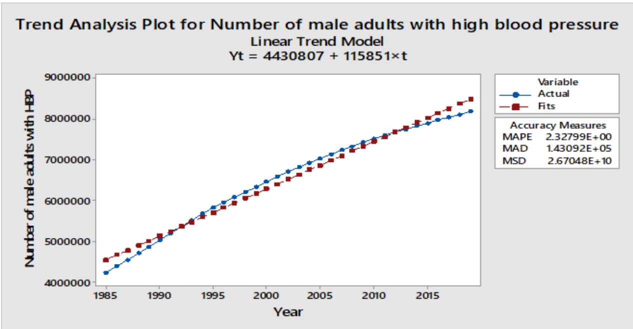

Fig. 9

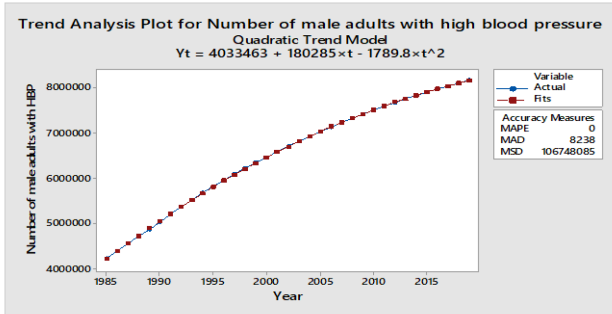

Fig. 10

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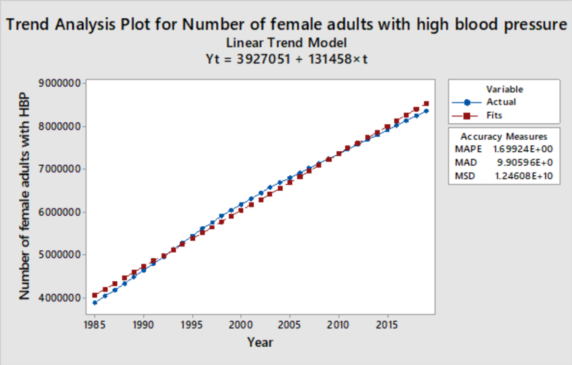

Fig. 11

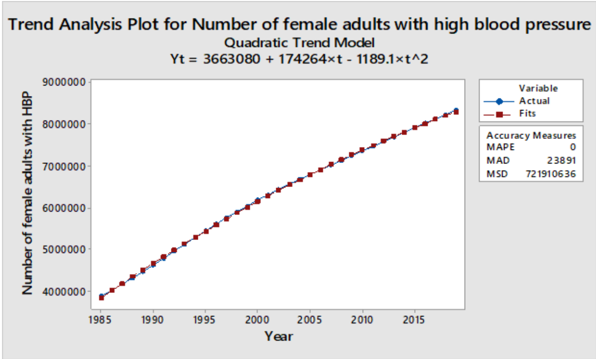

Fig. 12

Table 2: Summary of Trend Components for Male & Female with Diabetes & HBP for Linear and Quadratic Models

Accuracy Measures	DIABETES				HIGH BLOOD PRESSURE			
	MALE		FEMALE		MALE		FEMALE	
	Linear	**Quadratic**	Linear	**Quadratic**	Linear	**Quadratic**	Linear	**Quadratic**
R-square (R^2)	95.91%	**99.88%**	97.38%	**99.92%**	98.09%	**99.99%**	99.30%	**99.96%**
MAPE	11	**2**	7	**1**	2.32799	**0**	1.69924	**0**
MAD	82485	**14520**	58384	**9813**	143092	**8238**	990596	**23891**
MSD	9.35E+09	**2.79E+08**	4.78E+09	**1.37E+08**	2.67E+10	**10**	1.25E+10	**7.22E+08**

Footnote*: Bold values show the model of best fit* Interpretation

R^2 - It is also known as coefficient of determination. 0.90- 0.999 or 90% - 99.9%are considered very high and fall under the accepted range

MAPE - Mean Absolute Percentage Error: its measures the accuracy of fitted of trend component (time series). The Smaller values of MAPD indicate a better fit.

MAD - Mean Absolute Deviation is the average distance between each data value and the mean. A smaller MAD is more predictable

MSD - Mean Square Deviation is used to compare the fits of the different trend component models. Smaller values indicate a better fit.

From Table 2, comparing the linear and quadratic trend model with the values of the R^2 and accuracy measures (MAPE, MAD & MSD). It was observed the quadratic trend model is the better model that fits the data Sets

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Table 3: 2x 2 Contingency Table

Category	B_1= Diabetes	B_2 = High blood pressure	B = J
A_1 = Men	32880651	228064484	**260945134**
A_2 = Women	34756989	220265626	**255022615**
A = I	**67637640**	**448330109**	**515967749**
Odds	**0.946**	**1.035**	
Odds ratio	**0.914**		
	(1-0.914 = 0.086)		
Log odds ratio	**-0.09**		

From table 3; odds of men having diabetes = $\frac{32880651}{34756989} = 0.946$

odds of men having HBP = $\frac{228064484}{220265626} = 1.035$

odds ratio of men having diabetes vs HBP =$\frac{0.946}{1.035} = 0.914$; (1-0.914=0.086)

log odds ratio = $\ln(0.914) = -0.09$ (9% absolute value)

This implies that men having diabetes are 8.6% (≈9%) less likely to have high blood pressure than females

Table 4: Summary of Goodness-of-Fit Statistic for Log Linear Model

Model	df	Likelihood ratio (G^2)		Pearson chi square (X^2)	
		Value	Sig	Value	Sig
Independence	1	119745.750	0.000**	119749.712	0.000**
Saturated	0	0.0000	0.0000**	0.0000	0.0000**

Footnote: **= Sig. at 5%

Table 4 show the goodness-of-fit statistics for log linear model. It is observed that in the independence model the values of X^2=119749.712 and G^2 = 119745.750, df = 1 and p-value = 0.00 while in saturated model the values of X^2= 0 and G^2 = 0, df = 0, p-value = 0. This indicates that the independence model holds since the expected count are at least 5 we use Pearson (X^2)=119749.712, and p-value = 0.00 <($\propto$= 0.05). Therefore, we uphold the null hypothesis:

H_0: There is no relationship between the number of adult with Diabetes & HBP on gender basis

(Independence model $\ln(\mu_{ij}) = \lambda + \lambda_i^A + \lambda_j^B$holds)

And reject the alternative hypothesis:

H_1: There is relationship between the number of adult with Diabetes & HBP on gender basis

(Saturated model $\ln(\mu_{ij}) = \lambda + \lambda_i^A + \lambda_j^B + \lambda_{ij}^{AB}$ holds).

In addition, basic on the yearly average (or overall average cases), the data sets was classified into the **3-Way Log Linear Model** (2×2×2) table 5 below for the use of Minitab application.

Table 5: 2×2×2Contingency Table

Sex	Cases of Diabetes Mellitus		Cases of High Blood Pressure (HBP)	
	The Years (below or <) Average Cases	The Years (above or >) Average Cases	The Years (below or <) Average Cases	The Years (above or >) Average Cases
Male	11674174	21206478	86404613	141659870
Female	12483396	22273592	80569644	139695984

Minitab Statistical Software Result

```
Analysis of Variance
Source                                   DF        Adj SS         AdjMS  F-Value  P-Value
Regression     3  2.03548E+16  6.78494E+15     23.70     0.005**
  SEX                                     1  4.38453E+12  4.38453E+12     0.02     0.907
```

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Years above/below Average Cases	1	2.23460E+15	2.23460E+15	7.81	**0.049****
Cases of diabetes & high blood P.	1	1.81158E+16	1.81158E+16	63.29	**0.001****
Error	4	1.14499E+15	2.86248E+14		
Total	7	2.14998E+16			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
16918873	94.67%	90.68%	78.70%

Footnote: **=Sig. at 5%

Minitab 21 results show the 3-Way Log Linear Model (2×2×2) p-value (0.005) is significant at 5%, The R-Square value explains 90.68% of the variance in strength in model, indicating that this model fits the data set fairly well. R-Square (prediction) is 78.70%. There is a relationship between the numbers of adult with Diabetes & HBP at (p = 0.001**). Also, there is a relationship between the numbers of year's cases above/below the average cases of diabetes and high blood pressure at (p = 0.049**). However, there is no relationship between number cases of male and female adults at (p = 0.907).

From this results, it is observed that gender show no association in number of adult with Diabetes & HBP, while there is association in term of the number below and above the average cases of diabetes and high blood pressure and the numbers of adult with Diabetes & HBP.

Discussion

This study ascertain the relationship between diabetes mellitus and high blood pressure cases on gender using log linear analysis. Table 1 showed the descriptive statistics of male and female with cases of diabetes and high blood pressure over the years. The minimum of the cases was in 1985 and the maximum of the cases was in 2019 indicating that cases of diabetes and high blood pressure increases as the years goes by; it also showed that over the years diabetes are more in female than male and high blood pressure are more in male than female.Table 2 showed the trend components for male and female with DM and HBP cases using Ms-Excel and Minitab. It was observed that the quadratic model best fits the data. R^2 from quadratic model gives 99.88%, 99.92%for male and female with diabetes; 99.99%, 99.96% for the male and female with high blood pressure which is higher than the linear model with 95.1%, 97.38%, 98.09%, 99.3% respectively. The values of MAPE, MAD & MSD are smaller in the quadratic model compared to the linear model (Fig 1 to 12).

Table 3 showed the 2 x 2 contingency table (frequency distribution table) and the odds ratio. The odds ratio was 0.914 and P(odds ratio) = 1 – 0.914 = 0.086. This indicated that male having diabetes are 8.6% less likely to have high blood pressure than female, simply put, male with diabetes are at higher risk of having HBP than female.From table 4 using the log linear model of SPSS, the Pearson chi square X^2 = 119749.712 (large value) and p-value = 0.000 <∝= 0.05, showed that the independence model was the best model. Therefore, the null hypothesis was accepted showing that there is no relationship between the numbers of adult with Diabetes & HBP on gender basis.

Conclusion

Based on log linear analysis, it was concluded that even as diabetes is associated with high blood pressure, there is no relationship between DM and HBP on gender basis. The fact that males with DM cases are at high risk of having blood pressure does not mean that females will also have. It is therefore recommended that a study of forecasting the rate of cases of diabetes and high blood pressure be carried out by subsequent researchers.

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APPENDIX

Data for cases of Diabetes Mellitus and High Blood Pressure

Year	Male with Diabetes	Female with Diabetes	Male with HBP	Female with HBP
1985	320395	416064	4232344	3886264
1986	339025	433639	4389981	4025596
1987	359263	452755	4547922	4167955
1988	380843	473147	4708082	4314737
1989	404284	495408	4870105	4467130
1990	429926	520288	5033137	4625123
1991	456716	546403	5197110	4787986
1992	484468	573674	5360872	4953105
1993	514570	603554	5519687	5119123
1994	546333	635597	5673246	5284563
1995	580127	669992	5818141	5446323
1996	614384	704963	5955840	5603960
1997	648946	740655	6086545	5756274
1998	683713	776482	6212658	5903220
1999	719275	812537	6337946	6045766
2000	756004	849105	6460996	6182519
2001	795157	886953	6582390	6315804
2002	836574	926119	6701831	6444407

Year	Males with Diabetes	Female with Diabetes	Male with HBP	Female with HBP
2003	879925	966060	6815873	6567452
2004	924247	1005948	6924025	6685643
2005	970146	1046736	7028110	6799941
2006	1018308	1088927	7128749.	6912271
2007	1068620	1132138	7227490	7023798
2008	1122781	1177478	7323835	7134612
2009	1184193	1228143	7416075	7246534
2010	1247559	1280217	7504511	7357670
2011	1314203	1334842	7589346	7469083
2012	1384083	1392352	7671249	7580688
2013	1457353	1452768	7749102	7693055
2014	1533675	1515931	7823279	7804816
2015	1612388	1581703	7897219	7916878
2016	1693821	1650021	7967044	8025059
2017	1777532	1720225	8035068	8131399
2018	1864839	1793822	8103355	8238907
2019	1956975	1872340	8171319.288	8347967
Average	**939447**	**993057**	**6516128**	**6293304**

Source: NCD – Risc (Non – communicable disease Risk Factor Collaboration)

Basic on the yearly average (or overall average cases), the data sets was classified into the table below for **Log Linear Model** application;

Sex	Cases of Diabetes Mellitus		Cases of High Blood Pressure (HBP)	
	The Years (below or <) Average Cases	The Years (above or >) Average Cases	The Years (below or <) Average Cases	The Years (above or >) Average Cases
Male	11674174	21206478	86404613	141659870
Female	12483396	22273592	80569644	139695984

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Code used in Minitab Statistical Software

Response	SEX	Years above/below Average Cases of diabetes and high blood pressure.	Cases of diabetes and high blood pressure in term of gender
11674174	1	1	1
21206478	1	2	1
86404613	1	1	2
141659870	1	2	2
12483396	2	1	1
22273592	2	2	1
80569644	2	1	2
139695984	2	2	2

```
Welcome to Minitab Result
```

Regression Analysis: Response versus SEX, Years above/below Averag, Cases of diabetes and high blood pressure in term of sex

```
Method

Categorical predictor coding  (1, 0)


Analysis of Variance

Source                             DF        Adj SS        AdjMS  F-Value  P-Value
Regression                          3  2.03548E+16  6.78494E+15    23.70    0.005
  SEX                               1  4.38453E+12  4.38453E+12     0.02    0.907
  Years above/below Average Cases   1  2.23460E+15  2.23460E+15     7.81    0.049
  Cases of diabetes and high bloo1  1.81158E+16  1.81158E+16    63.29    0.001
Error                               4  1.14499E+15  2.86248E+14
Total                               7  2.14998E+16

Model Summary

       S    R-sq  R-sq(adj)  R-sq(pred)
16918873  94.67%     90.68%      78.70%

Coefficients

Term                                   Coef   SE Coef  T-Value  P-Value   VIF
Constant                             936713  11963450     0.08    0.941
SEX
  2                                -1480630  11963450    -0.12    0.907  1.00
Years above/below Average Cases
```

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```
  2                              33426024  11963450     2.79    0.049  1.00
Cases of diabetes and high blood P
  2                              95173118  11963450     7.96    0.001  1.00
```

Regression Equation

```
Response = 936713 + 0.0 SEX_1 - 1480630 SEX_2 + 0.0 Years above/below Average Cases_1
           + 33426024 Years above/below Average Cases_2
           + 0.0 Cases of diabetes and high bloo_1
           + 95173118 Cases of diabetes and high bloo_2
```

Regression Analysis: Response versus SEX, Years above/below Averag, Cases of diabetes and hi

Analysis of Variance

Source	DF	Adj SS	AdjMS	F-Value	P-Value
Regression	3	2.03548E+16	6.78494E+15	23.70	0.005
SEX	1	4.38453E+12	4.38453E+12	0.02	0.907
Years above/below Average Cases	1	2.23460E+15	2.23460E+15	7.81	0.049
Cases of diabetes and high bloo	1	1.81158E+16	1.81158E+16	63.29	0.001
Error	4	1.14499E+15	2.86248E+14		
Total	7	2.14998E+16			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
16918873	94.67%	90.68%	78.70%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-126181800	31652314	-3.99	0.016	
SEX	-1480630	11963450	-0.12	0.907	1.00
Years above/below Average Cases	33426024	11963450	2.79	0.049	1.00
Cases of diabetes and high bloo	95173118	11963450	7.96	0.001	1.00

Regression Equation

```
Response = -126181800 - 1480630 SEX + 33426024 Years above/below Average Cases
           + 95173118 Cases of diabetes and high bloo
```