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Influence of Age and Body Mass Index (BMI) On Blood Pressure using Multiple Regression Approach

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Abstract
Blood pressure: the force of circulating blood on the walls of the arteries. Blood pressure is taken using two measurements: systolic (measured when the heart beats, when blood pressure is at its highest) and diastolic (measured between heart beats, when blood pressure is at its lowest). Blood pressure is written with the systolic blood pressure first, followed by the diastolic blood pressure (for example 120/80). The only way to know if you have High Blood Pressure (HBP, or hypertension) is to have your blood pressure tested. The study aimed at determining the relationship of Age and Body Mass Index on Blood Pressure. The data used for this study was obtained from Solid Rock Hospital, Lagos State. People wondered if high blood pressure is a function of Age or the effect of Body Mass Index (BMI). A multiple regression analysis and Analysis of Variance (ANOVA) were adopted in the course of the study. The collected data were analysed using statistical package for social science $(version\ 23)$. *The result reveals that Age has significant relationship with systolic blood pressure and similarly BMI has relationship with systolic blood pressure since p-value is* 0.016 $(p < 0.05)$. *In a related development, the regression model* $(Systolic\ BP = 104.820 + 0.091AGE + 1.594BMI)$ *showed that increase in age and BMI resulted in HBP. It is hereby concluded that there is a relationship between age and blood pressure and in addition, a relationship exists between BMI and blood pressure.*

Keywords*: Age, Body Mass Index, Blood Pressure.*

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I. Introduction

Blood pressure (BP): the force of circulating blood on the walls of the arteries. The BP is taken using two measurements: Systolic (measured when the heart beats, when blood pressure is at its highest) and Diastolic (measured between heart beats, when blood pressure is at its lowest). Blood pressure is written with the systolic blood pressure first, followed by the diastolic blood pressure (for example 120/80). The authentic way to know if you have High Blood Pressure (HBP, or hypertension) is to have your blood pressure tested. Understanding your results is key to controlling high blood pressure. A diagnosis of HBP must be confirmed with a medical professional. A doctor should also evaluate any unusually low blood pressure readings.

The five blood pressure ranges, as recognized by the American Heart Association are: Normal Blood pressure numbers of less than 120/80 mm Hg are considered within the normal range. If your results fall into this category, stick with heart-healthy habits like following a balanced diet and getting regular exercise. Elevated: Elevated blood pressure is when readings consistently range from 120-129 systolic and less than 80 mm Hg diastolic. People with elevated blood pressure are likely to develop high blood pressure unless steps urgently are taken to control the condition. Hypertension Stage 1 is when blood pressure consistently ranges from 130-139 systolic or 80-89 mm Hg diastolic. At this stage of high blood pressure, doctors are likely to prescribe lifestyle changes and may consider adding blood pressure medication based on your risk of atherosclerotic cardiovascular disease (ASCVD), such as heart attack or stroke. Hypertension Stage 2 is when blood pressure consistently ranges at 140/90 mm Hg or higher. At this stage of high blood pressure, doctors are likely to prescribe a combination of blood pressure medications and lifestyle changes. Hypertensive crisis is the stage of high blood pressure that requires medical attention. If your blood pressure readings suddenly exceed 180/120 mm Hg, wait five minutes and then test your blood pressure again. If your readings are still unusually high, contact your doctor immediately. You could be experiencing an hypertensive crisis. If your blood pressure is higher than 180/120 mm Hg and you are experiencing signs of possible organ damage such as chest pain, shortness of breath, back pain, numbness/weakness, change in vision or difficulty speaking, do not wait to see if your pressure comes down on its own. Your blood pressure is recorded as two numbers:

- Systolic blood pressure (the first number) – indicates how much pressure your blood is exerting against your artery walls when the heart beats.
- Diastolic blood pressure (the second number) – indicates how much pressure your blood is exerting against your artery walls while the heart is resting between beats.

Typically, more attention is given to systolic blood pressure (the first number) as a major risk factor for cardiovascular disease for people over 50. In most people, systolic blood pressure rises steadily with age due to the increasing stiffness of large arteries, long-term build-up of plaque and an increased incidence of cardiac and vascular disease.

However, either an elevated systolic or an elevated diastolic blood pressure reading may be used to make a diagnosis of high blood pressure. According to recent studies, the risk of death from ischemic heart disease and stroke doubles with every 20 mm Hg systolic or 10 mm Hg diastolic increase among people from age 40 to 89. Blood pressure is the force of your blood as it flows through the arteries in your body. Arteries are blood vessels that carry blood from your heart to the rest of your body. When your heart beats, it pushes blood through your arteries. As the blood flows, it puts pressure on your artery walls. This is called blood pressure. Blood pressure is measured in mm Hg. The abbreviation mm Hg means millimetres of mercury. Mercury was used in the first accurate pressure gauges and is still used in medicine today as the standard unit of measurement for pressure. High blood pressure (also called hypertension) happens when your blood moves through your arteries at a higher pressure than normal. Many different things can cause high blood pressure. If your blood pressure gets too high or stays high for a long time, it can cause health problems. Uncontrolled high blood pressure puts you at a higher risk for stroke, heart disease, heart attack, and kidney failure.

High blood pressure is of types, viz:

Primary hypertension: This is also called essential hypertension. It is called this, when there is no known cause for your high blood pressure. This is the most common type of hypertension. This type of blood pressure usually takes many years to develop. It probably is a result of your lifestyle, environment, and how your body changes as you age.

Secondary hypertension: This happens when high blood pressure is caused through health problem or medicine. This type of hypertension is caused by:

- Kidney problems.
- Thyroid or adrenal gland problems.
- Some medicines.

Most people who have high blood pressure do not have symptoms. This is why it's sometimes called "the silent killer." More so, it's very important to have your blood pressure checked regularly.

Some people experience headaches, nosebleeds, or shortness of breath with high blood pressure. However, those symptoms can mimic many other things (serious or non-serious). Usually, these symptoms occur once blood pressure has reached a dangerously high level over a period of time. Common factors that can lead to high blood pressure include diet with high salt, fat, and/or cholesterol, chronic conditions such as kidney and hormone problems, diabetes, and high cholesterol, family history, especially if your parents or other close relatives have high blood pressure, lack of physical activity, older age (the older you are, the more likely you are to have high blood pressure), being overweight or obese, and so on.

Research Problem Statement

Several studies have shown that various factors like diet with high salt/fat/cholesterol, kidney and hormone problems, diabetes, among others, contribute to developing High Blood Pressure (HBP). These have been attributed to inability of going for regular medical check-up. Moreover, to the best of my knowledge, limited studies focused on age and Body Mass Index (BMI). Therefore, this study is aimed at determining the relationship between age and Body Mass Index (BMI) on blood pressure.

The Study Objectives

To achieve the aim of this study, the following objectives were executed:

- determining the effect of age on blood pressure
- To examine the effect of body mass index on blood pressure.

Hypotheses Statement

H_0^1: There is no relationship between Age being a factor to Blood Pressure.

H_0^2: There is no relationship between Body Mass Index as a factor that affect Blood Pressure.

II. Literature Review

Blood pressure (BP) is defined as lateral pressure exerted by the blood on the walls of the blood vessels while flowing through them. Blood pressure in a blood vessel depends upon two things-distance from the heart and nature of the blood vessel. Blood pressure is more in blood vessels close to the heart. Blood pressure is more in arterial system than in the venous system. This is because walls of arteries are thicker and less elastic, the walls of the veins are thinner and more elastic.

Increased salt intake of more than 5g per day increases blood pressure and alters the control of blood pressure in people with hypertension and people with normal blood pressure, in all age groups, and in all ethnic groups.

In a research, Aminu *et al.* (2015) studied the relationship between the Age, Body Mass Index (BMI) and High Blood Pressure (HBP). It was shown that strong and linear relationship existed between the level of blood pressure and BMI. Using statistical tools regression and correlation and also testing the significance of coefficient of regression, it was found that Age, BMI, Systolic and Diastolic are positively correlated and the regression model and the parameters are statistically significant.

According to Mostafa *et al.* (2015), it was revealed that blood pressure increased with the rise in BMI and weight but showed a negative correlation with height. Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) rose steadily with increasing age, but the rise in SBP was greater than DBP. Overweight and obese population, seemed to fall into the category of hypertensive. This was found in the paper titled "Blood pressure percentiles by age and body mass index for adults".

In their research titled "Body Mass Index relates to Blood Pressure among Adults", Suman *et al.*(2016) revealed that mean values of all the measurements, that is, height, weight, upper arm circumference, pulse rate, SBP and DBP were higher among males as compared with females except skinfold thicknesses. BMI and fat percentage was found to be higher among females as compared with males. There was a significant positive correlation between BMI, fat percentage, and blood pressure both SBP as well as DBP.

Study revealed that there were $424\,(53.0\%)$ males and $376\,(47.0\%)$ females, with a ratio of approximately $1:1$. Blood Pressure (BP) increased with age. The mean systolic and diastolic BP was significantly higher in females than males (Systolic $113.1mmHg\ v.\ 110.5mmHg$, and diastolic $69.0\ mmHg\ v.\ 66.5mmHg$, respectively; $p = 0.01$). Females had a higher BMI than males ($18.7kg/m^2$ v $17.9kg/m^2$, respectively; $p < 0.01$). BP increased as the BMI percentile increased. This is established by Isezuo *et al.*(2018) in their study who assessed blood pressure pattern and the relationship with BMI among apparently healthy secondary-school students in Sokoto Metropolis, Nigeria.

Meryem, (2018) studied the relationship between BMI and blood pressure in school-age children in Izmir, Turkey using independent sample t-test, ANOVA test and multiple regression analysis. It was discovered that the prevalence of hypertension and obesity was respectively 20.2% and 14.7%. Gender was not associated with hypertension and obesity in children. The body mass index was statistically significantly as an explanatory variable of hypertension for both genders.

Chen *et al* (2018), conducted a study on impact of body mass index on long-term blood pressure variability: a cross-sectional study in a cohort of Chinese adults. Their findings revealed that participants' average was $46.6\ \pm 11.3$ years, $24,502$ were men and $7,980$ were women. As BMI increases, the mean value of ARVSBP gradually increase. After adjusting for other confounding factors, stepwise multivariate linear regression analysis showed that ARVSBP increased by 0.077 for every one-unit increase in BMI. Multiple logistic regression analysis indicated that being obese or overweight, compared with being normal-weight, were risk factors for an increase in ARVSBP.

Findings according to Oyekale (2019) revealed that 25% of the women were either overweight or obese, while 13.28% were hypertensive. Women from the Greater Accra (18.15%), Ashanti (45.53%) and Volta (15.02%) regions had the highest incidences of hypertension. BMI and arm circumferences were truly endogenous and positively associated with the probability of being hypertensive. This is established in his paper titled "Effect of obesity and other risk factors on hypertension among women of reproductive age in Ghana: An instrumental Variable Probit Model".

III. Materials and Methods

Sources of Data Collection

The data for this research were gathered from secondary source. Data were obtained from the Health Information Management Department, Solid Rock Hospital, Lagos. The data contained the Age, Weight (kg), Height (cm), and Blood Pressure $(mmHg)$ of 500 people.

Method of Data Analysis

The data collected were analyzed using Multiple Regression approach.

Model Specification

The mathematical representation of linear regression is:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n$

Where

Y is dependent variable

$X_1, X_2, and\ X_3$ are independent variables.

IV. Results

The analysed data were presented using descriptive statistics, Analysis of Variance (ANOVA), charts and inferential statistics where applicable.

Descriptive Statistics of the Study Population

Table 1: Descriptive Statistics of the study population

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	500	21	60	30.61	4.936
WEIGHT(KG)	500	41	110	71.57	12.863
HEIGHT(CM)	500	101	191	161.54	10.933
HEIGHT(M)	500	1.01	1.91	1.6154	.10933
BMI	500	16.2	93.1	28.031	8.7224
BODY MASS INDEX	500	0	5	2.08	1.097
SYSTOLIC	500	80	163	110.93	14.543
DIASTOLIC	500	48	110	69.72	10.226
Valid N (listwise)	500				

Table 1 consists of Age, Weight, Height (cm), height (m), Body Mass Index, readings such as systolic and diastolic which has means and standard deviation values. Age mean= 30.61 standard deviation of age = 4.963, weight mean= 71.57 standard deviation of weight=12.863, height(cm) for mean= 161.54 standard deviation for height(cm)=10.933, height(m) for mean=1.6154 standard deviation for height(m)=0.10933, body mass index for mean=28.031 standard deviation for body mass index= 8.7224, body mass conversion=2.08 standard deviation for body mass conversion=1.097, systolic mean=110.93 standard deviation for systolic=14.543 diastolic mean=69.72 standard deviation for diastolic=10.226.

Table 2: Analysis of Variance $(ANOVA)$ where Systolic is dependent variable

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1736.808	2	868.404	4.158	.016[b]
	Residual	103796.600	497	208.846		
	Total	105533.408	499			

a. Dependent Variable: SYSTOLIC

b. Predictors: (Constant), BODY MASS INDEX, AGE

In the table 2 above, p-value (0.016) < (0.05), H_0 is rejected and it's concluded that there is relationship between age being a factor to blood pressure.

In the same vein, p-value (0.016) < (0.05), H_0 is rejected and it's concluded that there is relationship between body mass index as a factor that affects blood pressure.

Table 3: The fitted regression model

The regression model fitted is: Systolic BP= 104.820+ 0.091age + 1.594BMI.

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	104.820	4.119		25.449	.000	96.727	112.912
	AGE	.091	.132	.031	.689	.491	-.169	.351
	BODY MASS INDEX	1.594	.595	.120	2.678	.008	.424	2.764

a. Dependent Variable: SYSTOLIC

According to Table 3 above, it can be shown that an increase in Age results in 0.091 increase in Systolic Blood Pressure keeping BMI constant. Also, an increase in BMI results in 1.594 increase in Systolic Blood Pressure keeping Age constant. It is revealed that the relationship between Age and Systolic BP is -0.169 and 0.351 while the relationship between BMI and Diastolic BP is 0.424 and 2.764.

Table 4: Analysis of Variance $(ANOVA)$ where Diastolic is dependent variable

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	134.221	2	67.111	.641	.527[b]
	Residual	52049.691	497	104.728		
	Total	52183.912	499			

a. Dependent Variable: DIASTOLIC

b. Predictors: (Constant), BODY MASS INDEX, AGE.

Here, p-value (0.527) > 0.05, therefore H_0 is accepted and it is concluded that there is no relationship between age being a factor to blood pressure.

Also, p-value (0.527) > (0.005), therefore H_0 is accepted and it is concluded that there is no relationship between body mass index as a factor that affect blood pressure. This is as revealed in table 4.

Table 5: The fitted regression model

The regression model fitted is given by: Diastolic BP= 66.650+ 0.085age + 0.232BMI.

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	66.650	2.917		22.851	.000	60.919	72.380
	AGE	.085	.094	.041	.904	.367	-.099	.269
	BODY MASS INDEX	.232	.422	.025	.550	.583	-.596	1.060

a. Dependent Variable: DIASTOLIC

Table 5 shows that an increase in age will result in 0.085 increase in Diastolic Blood Pressure keeping BMI constant. Also, an increase in BMI will result in 0.232 increase in Diastolic Blood Pressure keeping age constant.
It's also revealed that the relationship between Age and Diastolic BP is -0.099 and 0.269 while the relationship between BMI and Diastolic BP is -0.596 and 1.060.

Fig. 1

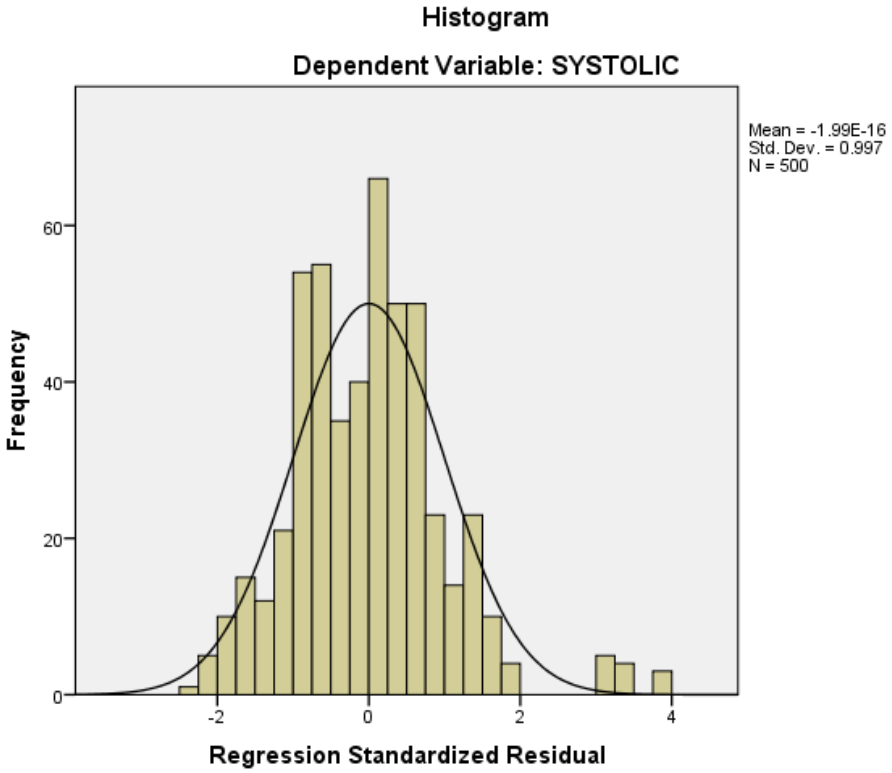
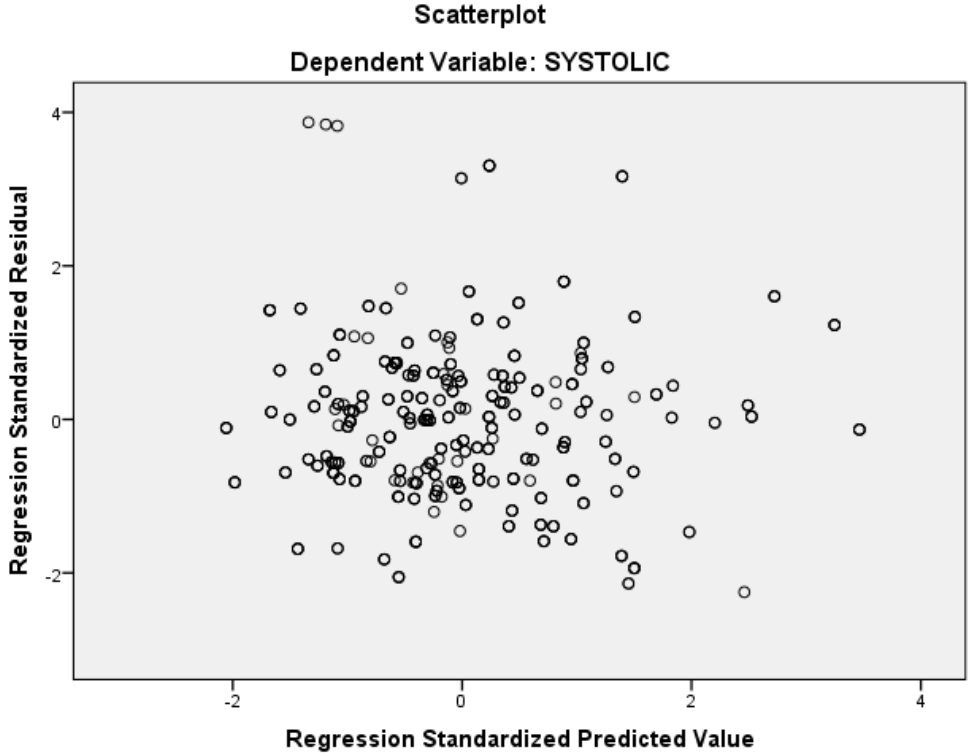


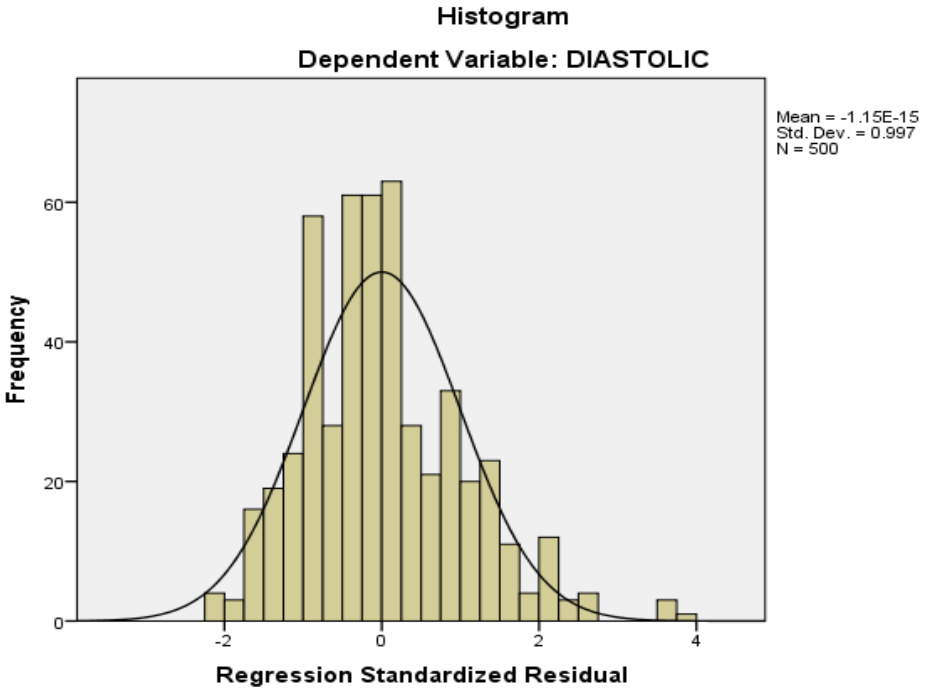
Fig. 1 revealed that the residuals are normally distributed with mean 1.99E-16 and standard deviation of 0.997.

Fig. 2



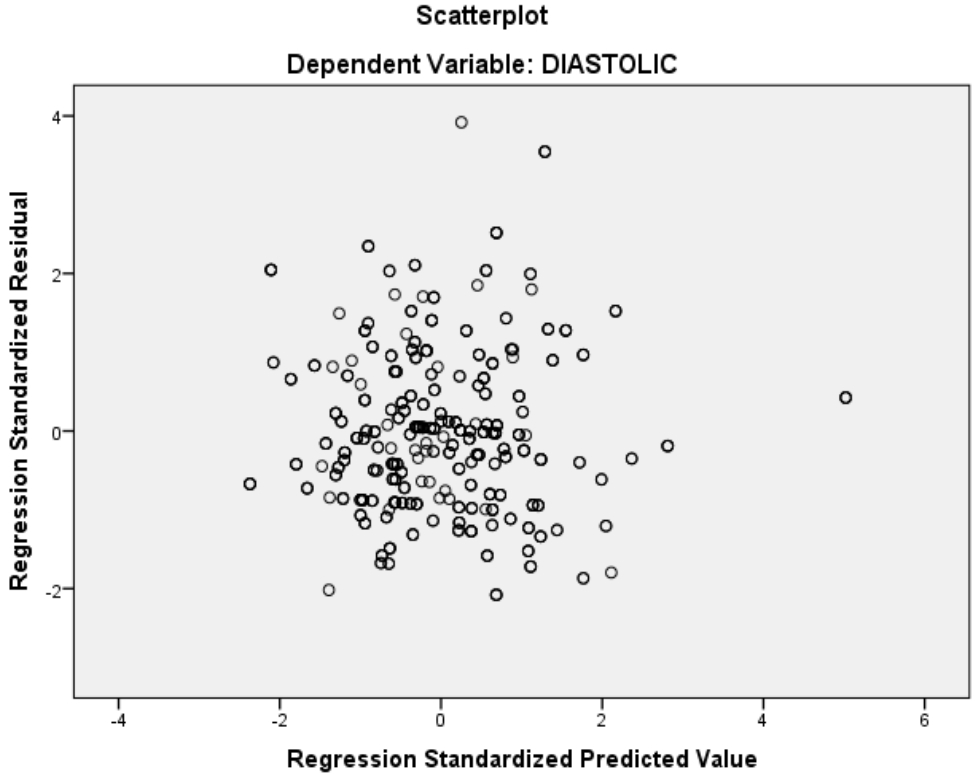
It was shown in Figure 2 that the data does not seem to resemble any kind of pattern which simply indicates no relationship exists between systolic blood pressure and Age and BMI.

Fig. 3



The residuals are normally distributed with mean $-1.15E-15$ and standard deviation 0.997. This is shown in Fig. 3 above.

Fig. 4



The data does not seem to resemble any kind of pattern which simply means there is no relationship between Diastolic Blood Pressure and Age and BMI. This is shown in Fig. 4.

V. Discussion

This study was conducted to determine the effect of age on blood pressure in addition to examining the effect of body mass index on blood pressure of 500 people in the hospital. It's shown that the age mean is 30.61, standard deviation of age is 4.963, weight mean is 71.57, standard deviation of weight is 12.863.

The finding also revealed that $p - value\ (0.016) < 0.05$ therefore, H_0 is rejected. Hence, it is concluded that there is relationship between age being a factor to blood pressure, so also there is a relationship between

BMI as a factor affecting blood pressure. This is in agreement with Meryem (2018), who in his study, concluded that BMI was statistically significant as an explanatory variable of high blood pressure. It was supported by Isezuo, *et al* (2018), who in their research, ascertained that relationship existed between blood pressure and BMI among apparently healthy secondary-school students in Sokoto.

Also, findings from this study has shown that increase in age results in 0.091 increase in Systolic Blood Pressure, keeping BMI constant and an increase in BMI results in 1.594 increase in systolic Blood Pressure while age is fixed. Additionally, a rise in age will increase Diastolic Blood Pressure by 0.085, keeping BMI constant and increase in BMI gives rise to Diastolic Blood Pressure by 0.232 while age is constant.

VI. Conclusion

The outcome of the study shows that no relationship exists between age, BMI and Diastolic blood pressure. Additionally, it can be affirmed there is relationship between age, being a factor to blood pressure. There is also a relationship between Body Mass Index as a factor that affects blood pressure.

VII. Recommendation

Based on the above conclusion, the followings recommendations were made:

1. The older ones should desist from excessive intake of sugar in order to reduce their blood pressure to a normal standard rate.
2. Anxiety is a major cause of High Blood Pressure among the old and the young, hence, anxiety should be properly worked on among each age group.
3. Necessary guidelines should also be provided by health care sectors so as to help out those people having High Blood Pressure readings for convenience and sustainability.

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