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Modeling Risk Factors of High Blood Pressure in Women Using Multiple Logistic Regression

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Abstract

This study employed the Multiple Logistic Regression (MLR) to model some risk factors of high blood pressure in women. Seven risk factors selected for this study were age, body mass index, waist circumference, skin fold thickness, pulse rate, mid arm circumference and hip circumference. Secondary data retrieved from the record unit of the University of Uyo Teaching Hospital, Uyo (UUTH) was used in this study. The risk factors were assessed from one hundred and ninety-three patients of the Hospital using MLR model. The findings revealed that there exist a significant influence of age and body mass index on high blood pressure. This result also showed that the higher the age of women, the more likely for them to have high blood pressure. The odds of high blood pressure in women who were obese were more than twelve times higher than women who were not obese. Other risk factors like waist circumference, skin fold thickness, pulse rate, mid arm circumference and hip circumference were not found to have significant influence on high blood pressure. Therefore, the result of the study showed that age and body mass index were the major risk factors of high blood pressure in women.

Keywords

Age; Body mass; Blood; Pulse; Regression

Introduction

The condition, high blood pressure today is of much concern to millions of people all over the world, not only has it sparked a lot of talk or attention, but it has also been ranked as a serious risk requiring serious attention. The term High blood pressure (hbp) is a gradual and silent operator that kills humans without symptoms. It is also used to describe hypertension. High blood pressure could be said to be a state or condition in which the blood vessels have persistently raised pressure and the higher the pressure in blood vessels, the harder the heart has to work in order to pump blood. The multiplicative effect of this sickness may result to a higher risk of getting stroke, kidney and heart diseases. Hbp could be described as either being systolic (the high and first number) or the diastolic (the lower and second number). Those who are observed to have systolic blood pressure of 140 mmHg or diastolic blood pressure of 90 mmHg are considered having high blood pressure. However, normal blood pressure is below 120/80. According to Qasim [1], this sickness is prevalent to all age groups while the adult patients are mostly affected by it through stress, too early marriages, family issues, low income and workload.

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The WHO [2] report reveals that the high blood pressure in Nigeria is high compared to most neighbouring countries and very few people are aware that they have the condition. However, high blood pressure does not maintain a steady state at all-time but depends on the activities that people involve in.

There exist a variety of risk factors associated with hypertension such as age, family issues, Body Mass Index (BMI), Physical Inactivity (PI), Waist Circumference (WC), Waist Hip Ratio (WHR), Hip Circumference (HC), Mid Arm Circumference (MAC), Pulse Rate (PR), Skin Fold Thickness (SFT) etcetera. For the purpose of this research, pulse rate, Body Mass Index, Waist Circumference, Skin Fold Thickness, Hip Circumference, and Mid Arm Circumference will only be taken into consideration. However, it is necessary to examine which among these risk factors is mostly associated with high blood pressure. It is on this backdrop that this research wishes to elicit the most risked factor that contributes significantly to high blood pressure in women using a multiple logistic regression model.

Statement of the Problem

Many people have little or no knowledge of what could be the major cause of high blood pressure. Over the past decades, extensive research, widespread patient education, and a concerted effort on the part of the health care professionals have led to decreased mortality rate from the multiple organ damage arising from years of untreated hypertension. Whereas many believe that high blood pressure is linked to family history or not engaging in physical activities, rarely people take into consideration a number of other factors that could contribute to it. The fact that high blood pressure is a major risk factor for some notable serious disease such as obesity, stroke, heart diseases, it is therefore pertinent to model the major leading risk factors causing high blood pressure in women using a multiple logistic regression technique.

Aim and Objectives

The aim of the study is to investigate the extent to which age, body mass index (BMI), pulse rate (PR), mid arm circumference (MAC), hip circumference (HC), skin fold thickness (SFT) and waist circumference (WC) contributes to high blood pressure. The objectives of this research work are:

a) To determine which factors are actually responsible for high blood pressure.

b) To fit a predictive reduced logistic regression model to the significant factors identified.

Review of Related Literature

Different scholars have researched on high blood pressure thereby enriching the literature. The work of Vasan et al. [3] as cited by Ali Shah et al. [4] estimated the remaining life span possibility for hypertension in both male and female adults of US citizens and found that 90% of respondents aging from 55 to 65 years were having high blood pressure. The study of Dennison et al. [5] observed that the cause of high blood pressure in South Africans were majorly smoking, alcohol usage and physical inactivity.

The work of Forman et al. [6] as cited by Ali Shah et al. [4] analysed the dietary and daily life risk factors of hypertension in women in Jamaica. They found that major risk factors of high blood pressure were obesity, age, family history of hypertension and smoking habit. In another development, Umoh and Jombo [7] observed that the causes of hypertension among young people aged 20-30 years in the out-patient clinic of the University of Uyo Teaching Hospital were life history, salt intake, smoking, waist circumference, body mass index. Akpan et al. [8] used multivariate regression models to examine the prevalence of high blood pressure between residents living in the urban and rural areas in Akwa Ibom State. Park and Kim [9] applied logistics regression to data obtained from women in Korea and concluded that their women suffered from high blood pressure compared to others. Abed and Abu-Haddaf [10] used a survey based method and applied multiple logistic in predicting the hypertension risk factors of residents. Hence, this work is therefore aimed at improving on some of the efforts made by the various researchers in the past which as stated aimed to determine the prevalence and risk factors associated with high blood pressure and how much these reported risk factors affect women.

Methodology

Logistic regression model

Logistic regression or logit model is a statistical method for analyzing a dataset in which there are one or more independent variables that determines an outcome. The outcome is measured with a dichotomous variable with only two possible outcomes. Logistic regression allows simultaneous investigation of many covariates, allowing separation of covariates effect and makes each effect more easily interpretable. It also allows construction of more complex models than the straight additive approach so that interaction among the covariates can be explored.

Multiple binary logistic regression model

The general logistic model with multiple explanatory variables is represented with n predictors for a binary response Y as $X_1, X_2,..., X_n$. We also use π (x) to represent the probability that Y = 1 for success, and 1 - π (x) to represent probability that Y=0.Π

These probabilities are written in the following form:

$$\pi(x) = P(Y=1|X_1, X_2, ..., X_n) \quad (1)$$

$$1 - \pi(x) = P(Y=0|X_1, X_2, ..., X_n) \quad (2)$$

The model for the log odds is:

$$\text{Logit}(\pi(x)) = In\frac{P(Y=1|X_1, X_2, ..., X_n)}{P(Y=0|X_1, X_2, ..., X_n)} \quad (3)$$

Which gives $\ln\left(\frac{\pi(x)}{1-\pi(x)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n + \varepsilon$ (4)

Or $In\left(\frac{\pi(x)}{1-\pi(x)}\right) = \beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon$

It is deduce by taking the exponent of both sides

$$\frac{\pi(x)}{1-\pi(x)} = e^{\beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon} \quad (5)$$

$$\pi(x) = e^{\beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon} - \pi(x)\left(e^{\beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon}\right)$$

$$\pi(x) + \pi(x)\left(e^{\beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon}\right) = e^{\beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon}$$

$$\pi(x)\left(1 + e^{\beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon}\right) = e^{\beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon}$$

$$\pi(x) = \frac{e^{\beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon}}{1 + e^{\beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon}}$$

$$\therefore \pi(x) = P(Y=1|X_1, X_2, ...X_n) = \frac{e^{\beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon}}{1 + e^{\beta_0 + \sum_{j=1}^{n}\beta_j X_j + \varepsilon}} \quad (6)$$

The parameter β_i refers to the effect of X_j on the log odds that Y=1 controlling the other predictor variables.

The resultant equation is got from the contribution of $\varphi(x_i)$ to the likelihood function for the observation $(x_i\ y_i)$:

$$\phi(x_i) = \pi(x_i)^{y_i}\left[1 - \pi(x_i)\right]^{1-y_i} \quad (7)$$

To get the likelihood function

$$l(\beta) = \prod_{i=1}^{n}\phi(x_i) = \prod_{i=1}^{n}\pi(x_i)^{y_i}\left[1-\pi(x_i)\right]^{1-y_i}$$

$$l(\beta) = \pi(x_i)^{\sum_{i=1}^{n}y_i}\left[1-\pi(x_i)\right]^{n-\sum_{i=1}^{n}y_i}$$

$$l(\beta) = \pi(x_i)^{\sum_{i=1}^{n}y_i}\left[1-\pi(x_i)\right]^{n}\left[1-\pi(x_i)\right]^{-\sum_{i=1}^{n}y_i}$$

$$l(\beta) = \left(\frac{\pi(x_i)}{1-\pi(x_i)}\right)^{\sum_{i=1}^{n}y_i}\left[1-\pi(x_i)\right]^{n} \quad (8)$$

Data Presentation, Analysis and Result

Data collected includes the distribution of Diastolic Blood Pressure (DBP) and Systolic Blood Pressure (SBP), Age, Pulse Rate (PR), Body Mass Index (BMI), Waist Circumference (WC), Skin Fold Thickness (SFT), Mid Arm Circumference (MAC) and Hip Circumference (HC) of 193 women in Uyo. Data obtained were analysed using Pearson's correlation and logistic regression model. To facilitate data analysis, the Statistical Package for Social Sciences was used.

The result in (Table 1) shows the correlation matrix among the variables under study. This reveals a significantly positive relationship between age and DBP (r=0.681, p<0.01), there was no significant relationship between age and systolic blood pressure (r=0.681, p>0.05). There was a significant relationship between waist circumference with diastolic blood pressure (r=0.237, p<0.01). Between waist circumference and systolic blood pressure there was no significant relationship (p>0.05). Body mass index was found to be significantly related with both SBP (r=0.215, p<0.01) and DBP (r=0.668, p<0.01). Pulse rate shows positive relationship with DB (r=0.452, p<0.05) and insignificant relationship with SBP (p>0.05). This result indicates that as the age, waist circumference, body mass index, mid arm circumference, and hip circumference increases, the diastolic blood pressure also increases significantly. Also, since BMI is the only risk factor that is significantly related with systolic blood

Table 1: Bivariate Relationship between the variables.

	Age	WC	SFT	SBP	DBP	BMI	MAC	HC	PR
Age	1								
WC	0.386**	1							
SFT	0.104	0.093	1						
SBP	0.121	0.047	0.016	1					
DBP	0.681**	0.237**	0.069	0.199**	1				
BMI	0.619**	0.214**	0.053	0.215**	0.668**	1			
MAC	0.329**	0.752**	0.040	0.064	0.198**	0.311**	1		
HC	0.345**	0.752**	0.060	0.046	0.258**	0.151*	-0.192**	1	
PR	0.480**	0.380**	0.035	0.117	0.452**	0.414**	0.235**	0.344*	1

**Significant at p<0.05, **significant at p<0.01.*

Table 2: Multiple logistic regression showing risk factor of HBP in women.

Risk Factors of hypertension	β	S.E	OR (95% C.I)	Wald Statistics	P-Value	Critical value $\chi^2_{(1)}$
Age	0.174	0.046	1.19 (1.087-1.302)	14.153	0.000	3.84
BMI	2.505	0.740	12.246 (2.871-52.224)	11.461	0.001	
WC	-0.092	0.084	0.912 (0.774-1.075)	1.209	0.271	
SFT	2.035	1.351	7.651 (0.542-108.027)	2.269	0.132	
PR	-1.023	1.016	0.360 (0.049-2.636)	1.013	0.314	
MAC	0.005	0.066	1.005 (0.883-1.144)	0.006	0.939	
HC	-0.004	0.060	0.996 (0.886-1.120)	0.005	0.944	

Constant 1.038

pressure, it means that as BMI increases, the systolic blood pressure also increases significantly.

The result summarized in (Table 2) reveals a significant influence of age on blood pressure (β=0.174, Wald Statistic=14.153, p=0.000, p<0.05). The result also shows that as the age increases, there is an increased risk of hypertension. This result also means that age contribute significantly to high blood pressure among women. Hence, we reject the null hypothesis and conclude that age has a significant influence on high blood in women.

Similarly, the result reveals a significant influence of Body Mass Index (BMI) on high blood pressure in women (β=2.505, Wald Statistics=1.461, p=0.001, χ^{12}=3.84). This conclusion was arrived at as the calculated value of Wald statistics (11.461) is greater than critical value of 3.84 at the 0.05 level of significant. The coefficient of 2.505 was obtained for BMI which means that as BMI increases, the blood pressure of women also increases. The odds of high blood pressure in women who were obese relative to their counterpart who were not obese was obtained to be 12.246 (C.I=2.871–52.224). Hence, women who were obsessed had more than twelve times likelihood of having high blood pressure than women who were not obese. Therefore, it is concluded that body mass index has significant influence on high blood pressure in women.

In another development, the result shows that the calculated value of Wald statistic (1.209) is less than its corresponding critical value (3.84) at 0.05 level of significance. Also, the p-value is greater than 0.05 (0.271>0.05). Therefore, there is no significant influence of waist circumference on high blood pressure among women.

Results presented in (Table 2) also reveals an insignificant influence of skin fold thickness on high blood pressure in women (β=2.035, Wald Statistics=2.269, p=0.132). This conclusion was arrived at as the calculated value of Wald statistics (2.269) is less than its corresponding critical value (3.84) at 0.05 level of significance. Also the p-value is greater than 0.05 (0.132>0.05). Therefore, we conclude that there is no significant influence of skin fold thickness on high blood pressure in woman.

The results as displayed in (Table 2) shows insignificant influence of pulse rate on high blood pressure in women β=-1.023, Wald statistics=1.013, p=0.314, p>0.05, χ^2 critical=3.84). This is because the calculated value of the test statistic (WS=1.013) is not greater than the critical value (3.84). Therefore, there is no significant influence of pulse rate on high blood pressure in women.

The results in (Table 2) reveals insignificant influence of mid arm circumference on high blood pressure in women (β=0.005, WS=0.006, p=0.939, p>0.05, χ^2 critical=3.84). This is because the calculated value of the test statistics (WS=0.006) is not greater than the critical value (3.84). Hence, there is no significant influence of mid arm circumference on high blood pressure in women.

Results in (Table 2) shows insignificant influence of hip circumference on high blood pressure in women (β=-0.004, WS=0.005, p=0.944, p>0.05, χ^2 critical=3.84).This is because the calculated value of the test statistics (WS=0.005) is not greater than the critical value (3.84). Therefore, there is no significant influence of hip circumference on high blood pressure in women.

Fitting in general model for risk factors of high blood pressure in women

The general model for the multiple logistic regression for the seven risk factors is

$$\ln\left(\frac{\pi(x)}{1-\pi(x)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 \quad (9)$$

Let $y = \ln\left(\frac{\pi(x)}{1-\pi(x)}\right)$

Table 3: Multiple logistic regression showing risk factor of high blood pressure women for reduced model.

Risk Factor of high blood pressure	β	S.E	Wald Statistics	p-value	OR(95%C.I)	Critical value $X^2_{(1)}$
Age (X_1)	0.168	0.040	17.403	0.000	1.183 (1.093-1.279)	
BMI (X_2)	2.768	0.704	15.475	0.000	15.922 (4.010 63.222)	
Constant	-5.601	1.209	21.461	0.004		

$$y = \frac{e^{\beta_0+\sum_{j=1}^{7}\beta_j X_j}}{1+e^{\beta_0+\sum_{j=1}^{7}\beta_j X_j}} \quad (10)$$

Based on the result in (Table 2)

β_o=1.038, β_1=0.174, β_2=2.505, β_3=-0.092, β_4=2.035, β_5=1.023, β_6= 0.005, β_7=0.004, X_1=age, X_2=Body Mass Index, X_3=WC, X_4=SFT, X_5= PR,

X_6=MAC, X_7=HC

Substituting β_o, β_1..., β_7 in equation (9) gives equation (10) below as the model

$$y = \frac{e^{-1.038+0.174X_1+2.505X_2-0.092X_3+2.035X_4+1.023X_5-0.004X_6}}{1+e^{-1.038+0.174X_1+2.505X_2-0.092X_3+2.035X_4+1.023X_5-0.004X_6}} \quad (11)$$

The reduced model for risk factors of high blood pressure in women

The risk factors like waist circumference (X_3), skin fold thickness (X_4), mid arm circumference (X_5), pulse rate (X_6) and hip circumference (X_7) were removed from the model because there contributions were not significant as shown in (Table 2). Hence, a reduced model was estimated using only age (X_1) and BMI (X_2).

The results in (Table 3) shows that out of the seven risk factors considered, age (X_1) and body mass (X_2) index were found to have significant influence on high blood pressure in women. The influence of other risk factors were not significant (p>0.05). Hence, the reduced model is thus:

$$y = \frac{e^{\beta_0+\beta_1 X_1+\beta_2 X_2}}{1+e^{\beta_0+\beta_1 X_1+\beta_2 X_2}} \quad (12)$$

After fitting the reduced model, results obtained is put into (12) to give (13) below.

β_o = -5.601, β_1= 0.168, β_2= 2.768

$$y = \frac{e^{-5.601+0.168X_1+2.768X_2}}{1+e^{-5.601+0.168X_1+2.768X_2}} \quad (13)$$

Summary

Based on the result of analysis, the findings reveal that:

(i) There is significant influence of age and body mass index on high blood pressure in women. This means that as their age's increase, the tendency of having high blood pressure increases in women. The odds of high blood pressure in women who were obese were twelve times higher than their counterpart women who were not obese.

(ii) There is no significant influence of skin fold thickness, pulse rate, mid arm circumference, hip circumference and waist circumference on high blood pressure in women.

Conclusion

This study has established significant influence of age and Body Mass Index on high blood pressure in women. Therefore, age and Body Mass Index are the major risk factors of high blood pressure. Hence, intervention programmes should focus on these factors to put a halt to the burden of high blood pressure in women.

Recommendation

The following were recommended based on the findings from the study.

1. Women should engage in regular weight check and physical activities.

2. Regular physical exercise at least thrice weekly is recommended for woman.

3. There is need for more health education in public places and institutions and through the media to curb the impending global epidemic of hypertension.

4. Measures should be put in place to curb the tendency to sedentary life style among women.

5. Hypertension control programmes needs to be established for women.

6. Anti-hypertensive drugs should be made available and affordable to all hypertensive patients.

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