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A Binary Logistic Regression Analysis on the Factors Associated with High Blood Pressure and Its Related Heart Issues

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Abstract: Hypertension (High Blood Pressure) is a major public health issue and an important research topic because of its great incidence and role as a key risk factor for cardiovascular disease and other consequences. The goal of this study is to determine the association between gender and blood pressure, as well as to determine which race suffers the most from high blood pressure among study participants. It may be concluded from the findings of this study that elderly persons have a larger risk of high blood pressure than younger people. High blood pressure is also more common in African Americans (AA) than in other races. Women are more likely than men to have high blood pressure, and smokers are more likely than nonsmokers to have high blood pressure. Physical activity aids in the burning of calories, which aids in weight loss. As a result, thick and hefty persons have a larger risk of high blood pressure than small people. Obesity and advancing age have been shown to be independent risk factors for high blood pressure. Improvements to surveillance systems are required, as is the introduction of community-based screening programs for the early detection of high blood pressure. Because there was a lack of understanding of high blood pressure among high blood pressure patients, improving health literacy to raise awareness of high blood pressure is also a pressing necessity. Weight control improved physical activity, increased fruit and vegetable consumption, and smoking ban are all essential and suggested interventions.

Keywords: Blood Pressure, Cardiovascular Diseases, Hypertension, Obesity

1. Introduction

Cardiovascular diseases (CVDs) are the world's leading cause of death, claiming the lives of an estimated 17.9 million people per year. Coronary heart disease, cerebrovascular disease, rheumatic heart disease, and other illnesses are included in the group of heart and blood vessel disorders known as CVDs [1]. More than four out of every five CVD deaths are caused by heart attacks and strokes, and one-third of these deaths happen before the age of 70 [2]. The main behavioral risk factors for heart disease and stroke are poor diet, inactivity, smoking, and excessive alcohol use [3]. As a result of behavioral risk factors, people may have symptoms like high blood pressure, high blood sugar, high blood lipids, and overweight or obesity. A higher risk of heart attack, stroke, heart failure, and other repercussions is suggested by these intermediate-risk variables, which can be evaluated in basic healthcare settings [4]. Tobacco cessation, salt reduction in the diet, increased fruit and vegetable consumption, regular physical activity, and avoidance of problematic alcohol usage have all been demonstrated to lessen the risk of cardiovascular disease. Health policies that foster conditions that make healthy options affordable and accessible are critical for

encouraging people to develop and maintain healthy habits [5].

High blood pressure is the major risk factor and the cause of heart disease. The extremely high blood pressure in your arteries and other blood vessels is a medical condition. To lessen your risk of heart disease and heart stroke, you can lower your blood pressure with lifestyle modifications or medication [6]. High blood pressure, heart disease, and other related disorders are likely to be influenced by genetic factors. A higher likelihood of shared environments and other variables that may increase risk exists in those with a family history of heart disease [7]. Several foods include cholesterol, a waxy, fatty substance produced by the liver. If we ingest more cholesterol than our systems can utilize, extra cholesterol may accumulate in the walls of arteries, particularly those of the heart. As a result, the arteries constrict, decreasing blood flow to the heart, brain, kidneys, and other bodily organs. High blood cholesterol typically has no symptoms or warning signals [8]. Your body requires glucose for energy (sugar). The pancreas secretes the hormone insulin, which facilitates the transfer of dietary glucose to your body's cells for energy. If you have diabetes, your body either produces insufficient insulin, can't effectively utilize it, or both. Diabetes causes a buildup of sugar in the bloodstream [9]. The definition of obesity is having too much body fat. Diabetes, heart disease, and high blood pressure have all been connected to obesity. Smoking raises your chances of developing heart disease and having a heart attack. Cigarette smoking can harm your heart and blood arteries, increasing your risk of cardiac problems such as atherosclerosis and heart attacks [10]. Identification of risk factors is a must before effective prevention strategies can be implemented. The goal of this research is to learn more about the factors that contribute to high blood pressure and the heart problems that come with it.

1.1. Objectives of the Study

The objectives of this study were;

1) To investigate the relationship between gender and blood pressure.
2) To determine the races that suffered most as a result of high blood pressure.
3) To determine whether high blood pressure was caused by obesity.
4) To investigate whether smoking affected blood pressure.

1.2. Research Questions

Our research aimed to address the following questions:

1) What is the relationship between gender and blood pressure?
2) Which races suffer as a result of high blood pressure?
3) Is high blood pressure caused by obesity?
4) Does smoking affect blood pressure?

1.3. Literature Review

Globally, cardiovascular diseases (CVDs) constitute the leading cause of mortality. In 2019, 17.9 million people died globally from CVDs, which made up 32% of all fatalities. 85 percent of these fatalities were caused by heart attacks and strokes [1]. More than 75 percent of CVD mortality occurs in low- and middle-income countries [11]. 38 percent of the 17 million premature deaths (before the age of 70) attributable to noncommunicable illnesses in 2019 were caused by CVDs [1]. By addressing behavioral risk factors including smoking, poor nutrition and obesity, inactivity, and excessive alcohol use, most cardiovascular diseases may be prevented. It is essential to identify cardiovascular disease as soon as possible so as to begin medical care with counseling and medication, [5].

Cardiovascular diseases (CVDs) are a group of disorders of the heart and blood vessels. They include:

1) Coronary heart disease is a condition that affects the blood arteries that nourish the heart muscle.
2) Cerebrovascular disease (CVD) is a condition that affects the brain's blood arteries.
3) Peripheral arterial disease (PAD) is a condition that affects the blood arteries that deliver blood to the arms and legs.
4) Rheumatic heart disease — rheumatic fever, which is caused by streptococcal bacteria, damages the heart muscle and heart valves.
5) Congenital heart disease - birth abnormalities that disrupt the heart's normal development and function as a result of malformations in its structure from birth; and
6) Pulmonary embolism and deep vein thrombosis — blood clots in leg veins that might dislodge and go to the heart and lungs.
7) A blockage that stops blood from getting to the heart or brain usually results in abrupt events like heart attacks and strokes. The most frequent cause is an accumulation of fatty deposits on the inner walls of the blood vessels that supply blood to the heart or brain [6]. Blood clots or bleeding from a brain artery are the two main causes of strokes. The most significant behavioral risk factors for heart disease and stroke include eating unhealthy foods, being physically inactive, smoking, and drinking alcohol in moderation [2]. Behavioral risk factors can manifest as elevated blood pressure, elevated blood glucose, elevated blood lipids, and being overweight or obese [10]. There are several underlying elements that have an impact on CVDs. The main factors influencing social, economic, and cultural change are globalization, urbanization, and population aging. Genetics, stress, and poverty are additional CVD predictors [7]. Additionally, to reduce cardiovascular risk and stop heart attacks and strokes in people with these conditions, pharmaceutical therapy for hypertension, diabetes, and high blood lipids is necessary. [5] Low-income and middle-income nations account for at least three-quarters of all CVD deaths worldwide. People in low- and middle-income countries frequently lack access to basic health care services that allow for early detection and treatment of people with CVD risk factors. People with CVDs and other noncommunicable illnesses in low- and middle-income countries have reduced access to effective and equitable health care services that meet their needs. As a result, in many of these nations, disease identification occurs late in the course of the disease, and

people die of CVDs and other non-communicable diseases at a younger age, often during their most productive years. The poorest individuals in low- and middle-income countries are the ones who bear the brunt of the consequences. Evidence is accumulating that CVDs and other noncommunicable illnesses due to catastrophic health spending and excessive out-of-pocket costs, cause household impoverishment. CVDs impose a significant economic burden on the economies of low- and middle-income countries [11]. Women and men's cholesterol levels rise as they age. Before menopause, women's total cholesterol levels are lower than men's total level at the same age. Women's cholesterol levels have been observed to climb after they reach menopause.

2. Methodology

2.1. Sampling Technique

A stratified sampling technique was used to get the respondents for the study, which was conducted in Birmingham. This sampling technique was chosen because we wanted to divide the population into smaller groups that do not overlap. This is because we wanted to consider respondents from different races: African American (AA), American Indian (AI), Native Hawaiian (NH), Pacific Islander (PI), and Non-Hispanic White (NHW). In that case, every race would be studied thoroughly and explicitly.

Formula for getting a sample size using stratified sampling technique

The objective of stratification was to produce estimators of sample sizes for each stratum (different races) such that with each stratum, the units are as similar as possible. The stratification was based on the different races in the United States of America.

$$n_h = \frac{n.N_h}{N}$$

Where n is the total sample size, N is the population size, N_h is the size of the stratum, and n_h is the size of the sample selected from the h^{th} stratum. The five different strata are AA, AI, NH, PI, and NHW.

$$N = 10000, n = 500$$

$$N_{AA} = 3000, n_{AA} = \frac{3000 \times 500}{10000} = 150$$

$$N_{AI} = 2800, n_{AI} = \frac{2800 \times 500}{10000} = 140$$

$$N_{A} = 1500, n_{A} = \frac{1500 \times 500}{10000} = 75$$

$$N_{NH} = 1300, n_{NH} = \frac{1300 \times 500}{10000} = 65$$

$$N_{PI} = 800, n_{PI} = \frac{800 \times 500}{10000} = 40$$

$$N_{NHW} = 600, n_{NHW} = \frac{600 \times 500}{10000} = 30$$

2.2. Research Design

An appropriate Research design was needed to strategize how respondents would answer the research questions. In that regard, descriptive and correlational designs were used to allow us to measure variables and describe relationships between them. These well-planned research designs helped ensure that the method matched the research aims and objectives.

3. Data Analysis

Descriptive statistics

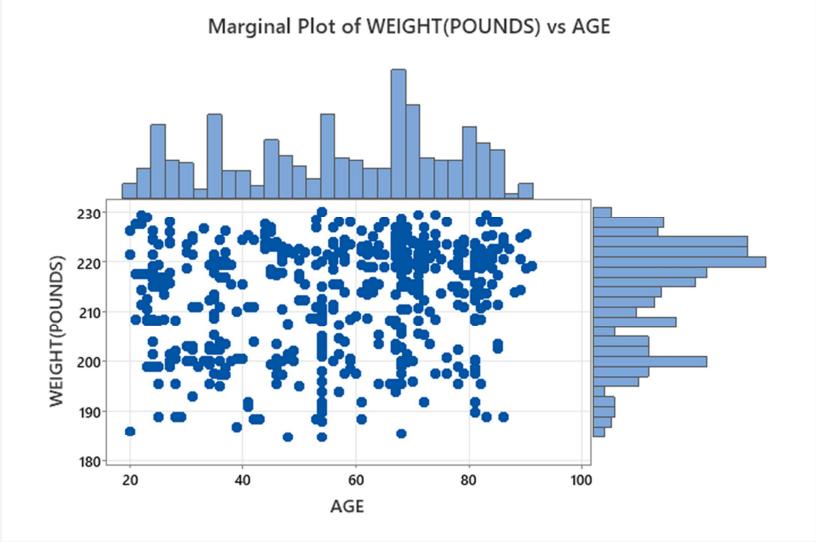

Figure 1. *Marginal plot of Weight (pounds) vs Age.*

The marginal plot is used to assess the relationship between the weight and age of respondents. It examines the distributions of weight and age. The marginal plot indicates that the data has no outliers. Thus, no other extraneous factors affect the data. Since the data points in the marginal plot are scattered randomly, it implies that there is no relationship or correlation between weight and age. Thus, weight cannot predict age and vice versa. Thus, older people are not heavier than younger people and vice versa.

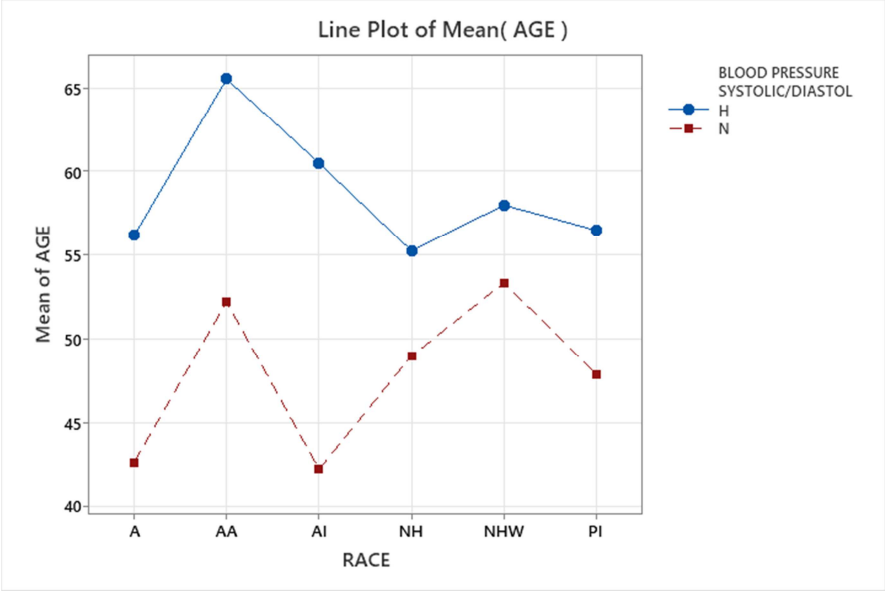

Figure 2. *Line plot of mean (Age).*

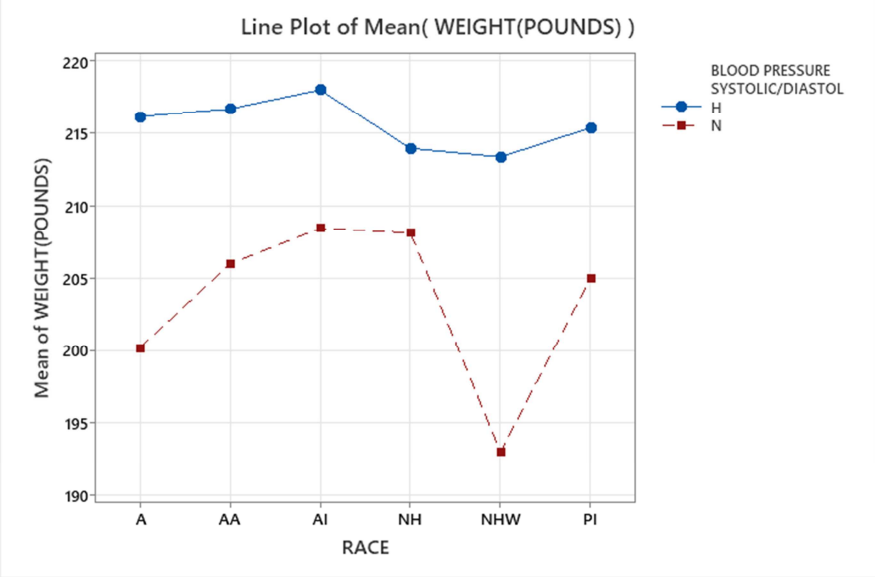

Figure 3. *Line plot of mean (Weight (Pounds)).*

From the line plot of the mean (AGE), generally, it was observed that older people had higher blood pressure than young people. Thus, older people are at a higher risk of having high blood pressure as compared to young people. High blood pressure is more prevalent among African Americans (AA) than among the other races.

From the line plot of the mean (WEIGHT), generally, it was observed that thick and heavy people (obese) had higher blood pressure than slim people. Engaging in physical exercise would help burn calories which in turn help reduce weight. Thus, thick and heavy people are at a higher risk of having high blood pressure as compared to slim people.

Results and interpretation

Table 1. *Response Information.*

Variable	Value	Count
Blood Pressure Systolic/Diastol	N	142 (Event)
	H	358
	Total	500

Table 2. *Coefficients.*

Term	Coef	SE Coef	Z-Value	P-Value	VIF
Constant	27.77	3.35	8.28	0.000	
AGE	-0.05212	0.00893	-5.84	0.000	1.29
WEIGHT (POUNDS)	-0.1138	0.0149	-7.61	0.000	1.34
RACE					
AA	-0.220	0.465	-0.47	0.636	2.10
AI	-0.036	0.466	-0.08	0.939	2.03
NH	-0.439	0.536	-0.82	0.413	1.65
NHW	-0.526	0.689	-0.76	0.445	1.37
PI	-0.152	0.625	-0.24	0.808	1.43
SEX					
W	-0.058	0.295	-0.20	0.844	1.03
SMOKING					
Y	-3.676	0.366	-10.05	0.000	1.51

The table above was used to determine whether the association between high blood pressure and each of the predictor variables is statistically significant. From the table above (p-value), age, weight, and smoking habits are statistically significant. Sex and race are not statistically significant. This means that whereas age, weight, and smoking habits contribute to the prediction of blood pressure, race and sex do not contribute to the prediction of blood pressure.

Negative coefficients indicate that the event becomes less likely as the predictor increases whereas positive coefficients indicate that the event becomes more likely as the predictor increases. From the table above, the coefficients of age, weight, and smoking suggest that higher age, weight (obesity), and excessive smoking are associated with lower probabilities that the event (Normal blood pressure) will occur.

Table 3. *Analysis of Variance.*

Source	DF	Wald Test	
		Chi-Square	P-Value
Regression	9	117.03	0.000
AGE	1	34.06	0.000
WEIGHT (POUNDS)	1	57.99	0.000
RACE	5	1.28	0.937
SEX	1	0.04	0.844
SMOKING	1	101.07	0.000

From the ANOVA table above, the logistic regression model is statistically significant. Even though the overall regression model is statistically significant, some of the predictor variables (RACE, SEX) are not statistically significant.

Table 4. *Odds Ratios for Continuous Predictors.*

	Odds Ratio	95% CI
AGE	0.9492	(0.9327, 0.9660)
WEIGHT (POUNDS)	0.8924	(0.8666, 0.9189)

Odds ratios that are greater than 1 indicate that the event is more likely to occur as the predictor increases. Since the odds ratios are less than 1 for both age and weight, we conclude that the event (Normal blood pressure) is less likely to occur as age and weight increase. Thus, high blood pressure occurs as a result of old age and obesity.

The odds ratio for level A relative to level B.

Table 5. *Odds Ratios for Categorical Predictors.*

Level A	Level B	Odds Ratio	95% CI
RACE			
AA	A	0.8027	(0.3229, 1.9955)
AI	A	0.9651	(0.3870, 2.4069)
NH	A	0.6450	(0.2258, 1.8426)
NHW	A	0.5910	(0.1531, 2.2815)
PI	A	0.8593	(0.2527, 2.9226)
AI	AA	1.2022	(0.5491, 2.6324)
NH	AA	0.8035	(0.3156, 2.0453)
NHW	AA	0.7362	(0.2089, 2.5947)
PI	AA	1.0705	(0.3484, 3.2890)
NH	AI	0.6683	(0.2598, 1.7194)
NHW	AI	0.6124	(0.1697, 2.2094)
PI	AI	0.8904	(0.2875, 2.7572)
NHW	NH	0.9163	(0.2345, 3.5803)
PI	NH	1.3323	(0.3843, 4.6188)
PI	NHW	1.4540	(0.3234, 6.5380)
SEX			
W	M	0.9436	(0.5297, 1.6807)
SMOKING			
Y	N	0.0253	(0.0124, 0.0518)

Odds ratios for categorical predictors

For categorical predictors, if the odds ratio is less than 1, then it implies that the event (Normal blood pressure) is less likely to occur at level A. On the contrary, if the odds ratio is greater than 1, then it implies that the event (Normal blood pressure) is more likely to occur at level A.

Race

From the table above, Normal blood pressure is less likely to occur at AA than at A. Thus, AA is more likely to have a high blood pressure than A. Normal blood pressure is less likely to occur at AI than at A. Thus, AI is more likely to have a high blood pressure than A. Similarly, Normal blood pressure is less likely to occur at NH, NHW, and PI than at A. Thus, NH, NHW, and PI are more likely to have a high blood pressure than A.

From the table above, Normal blood pressure is less likely to occur at AI and PI than at AA whereas Normal blood pressure is more likely to occur at NH and NHW than at AA. Thus, AI and PI are more likely to have a high blood pressure than AA while NH and NHW are more likely to have Normal blood pressure than AA.

Again, Normal blood pressure is less likely to occur at NH, NHW, and PI than at AI. Thus, NH, NHW, and PI are more likely to have a high blood pressure than AI.

Normal blood pressure is less likely to occur at NHW than at NH whereas Normal blood pressure is more likely to occur at PI than at NH. Thus, NHW are more likely to have a high blood pressure than NH while PI are less likely to have a high blood pressure than NH.

Normal blood pressure is more likely to occur at PI than at NHW. Thus, PI is less likely to have high blood pressure than NHW.

Sex

Women are less likely to have a normal blood pressure than men. Thus, women tend to have a high blood *pressure than men.*

Smoking

People who smoke are more likely to have a high blood pressure than those who do not smoke. This implies that smoking tends to affect heart conditions.

DEVIANCE R-sq, Deviance R-sq (adj) and AIC

To determine how well the model fits the data, examine the statistics in the Model Summary table. The data format affects the deviance R^2 statistics but not the AIC. The higher the deviance R^2, the better the model fits the data. The smaller the AIC, the better the model fits the data.

Table 6. *Model Summary.*

Deviance R-Sq	Deviance R-Sq (adj)	AIC	AICc	BIC	Area Under ROC Curve
87.15%	84.64%	23.45	23.90	65.59	0.7284

In these results, the model explains 87.15% of the deviance in the response variable. The Deviance R^2 value indicates that the model provides a good fit to the data. Similarly, a high adjusted Deviance R^2 value and a small AIC value indicate that the model fits the data well.

Goodness of fit test

The goodness-of-fit-test is used to determine whether the predicted probabilities deviate from the observed probabilities in a way that the binomial distribution does not predict. If the p-value for the goodness-of-fit test is lower than the significance level of 0.05, then the predicted probabilities deviate from the observed probabilities in a way that the binomial distribution does not predict. If the p-value is less than 0.05, then the deviation is statistically significant and thus a different link function or change the terms in the model.

For binary logistic regression, the format of the data affects the p-value because it changes the number of trials per row.

Table 7. *Goodness-of-Fit Tests.*

Test	DF	Chi-Square	P-Value
Deviance	490	303.45	0.549
Pearson	490	397.18	0.848
Hosmer-Lemeshow	8	6.92	0.446

In these results, the goodness-of-fit-tests p-values are greater than the significance level of 0.05, which indicates that there is not enough evidence to conclude that the model does not fit the data.

4. Conclusions and Recommendations

It may be concluded from the findings of this study that elderly persons have a larger risk of high blood pressure than younger people. High blood pressure is also more common in African Americans (AA) than in other races. Women are more likely than men to have high blood pressure, and smokers are more likely than nonsmokers to have high blood pressure. Physical activity aids in the burning of calories, which aids in weight loss. As a result, thick and hefty persons have a larger risk of high blood pressure than small people. Obesity and increasing age have been shown to be independent risk factors for high blood pressure. Improvements to surveillance systems are required, as is the introduction of community-based screening programs for the early detection of high blood pressure. Because there was a lack of understanding of high blood pressure among high blood pressure patients, improving health literacy to raise awareness of high blood pressure is also a pressing necessity. Weight control improved physical activity, increased fruit and vegetable consumption, and smoking ban are all essential and suggested interventions.

5. Limitation

The following are some of the study's limitations: (i) The study was only conducted in an urban area. (ii) An important risk factor for hypertension is stress. For improved outcomes, it could also be considered in the current investigation.

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