

PREDICTION OF HYPERTENSION USING ITS RISK FACTORS: A CASE CONTROL STUDY IN AZIZ BHATTI SHAHEED HOSPITAL

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ABSTRACT: Hypertension is becoming the major risk factor of the cardiovascular diseases. Hypertension is also known as “raised blood pressure” in medical terms. The main purpose of this study is to identify the potential risk factor of hypertension using chi-square test of association and also predict and classify the respondents into hypertension and healthy controls by Artificial Neural Network (ANN). A sample of 300 (150 cases and 150 controls) were selected using purposive sampling from Aziz Bhatti shaheed Hospital Gujrat, Pakistan. Data collected by interviewing the patients using well-designed questionnaire and checked their BP where cases considered as hypertension patients with (BP: $\geq 140/90$) and healthy controls (BP: $\leq 120/80$). High prevalence of hypertension is observed in males (54.7%) as compared to females (45.3%). Results also revealed that BMI, family income, age, extra salt intake and stress were the significant risk factors of hypertension in current study. ANN model showed good classification among hypertension and controls. It also predicted 98% chance of patient to have hypertension on the basis of age group 50-59 years, having normal weight, belongs to middle class family, presence of BP issue in family history, take stress and extra salt consumption in diet.

Keyword: Artificial Neural Network, Hypertension, Body Mass Index, Income, Stress, Age.

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INTRODUCTION

In developed and developing countries major reason for the death and disability is cardiovascular diseases (CVD). Hypertension is the seventh contributor in developing countries while fourth contributor in developed countries is to premature deaths [1]. Many epidemiological studies confirmed hypertension as major risk factor for CVD [2]. World Health Organization (WHO) in 2016 had revealed hypertension is estimated to cause deaths about 12.8% (7.5 million) of the total deaths in worldwide. Around the world, approximately 31% deaths occur due to CVD. Greater than 75% of CVD death occurred in low income or middle-income countries and 85% of all CVD deaths are due to heart attack and strokes [3]. In addition, 972 million adults with hypertension are found of which 333 million in economically developed countries and 639 million in economically developing countries. This prevalence rate is predicted to increase upto 60% in 2025.⁵ Mostly people with high BP issue not having any symptoms but, in some cases, it may cause symptoms such as severe headache and stomach pain, shortness of breath, dizziness, chest pain, feeling vomiting and suffocation. Raised blood pressure can be dangerous and sometime called the “Silent Killer” if you are living with this

dangerous condition that risk of heart attack and stroke is 2-4 times greater between 6 am and noon. One of the three adults worldwide has high BP issue and this proportion increases with the increase of age [4] [5].

Hypertension is a medical condition when the systolic blood pressure of a person is consistently 140 mm Hg (millimeters of mercury) or greater and his diastolic blood pressure is consistently 90 mm Hg or greater [6]. In twin cities of Pakistan, high prevalence (29.40%) of hypertension is observed, 62.80% patients were not interested in maintaining their health and 7.8% were taking medicine to control blood pressure [7]. the awareness regarding hypertension was observed in average income as compared to lower income people of Pakistan [8]. But there is no sufficient documentary evidence regarding the awareness of hypertension among patients in Pakistan population [9]. Obesity and age are the most associated risk factors of high BP and obesity was reported in Rawalpindi-Islamabad by (59.4%) [7]. It is also revealed that 15.6% prevalence of hypertension associated with age and BMI. High blood pressure is common in the aged people with age 50 or above years. As the age increases, structural changes occur in the arteries and also blood pressure can also increase gradually [10]. In China, strong positively association was observed among BMI and high blood pressure where

hypertension is going to be more prevalent and obesity is increasing [11].

Stress as the major risk factor of cardiovascular diseases and hypertension. Statistically higher mean mental stress scores of hypertensive were found in hypertensive and in both gender, male had higher stress score [12].

The present study was designed to explore the association between hypertension and demographic variables (age and BMI) stress, excessive salt intake and lack of physical activities. The objective was to classify and predict chance of visitors of presence and absence of hypertension by significant factors.

MATERIAL AND METHODS

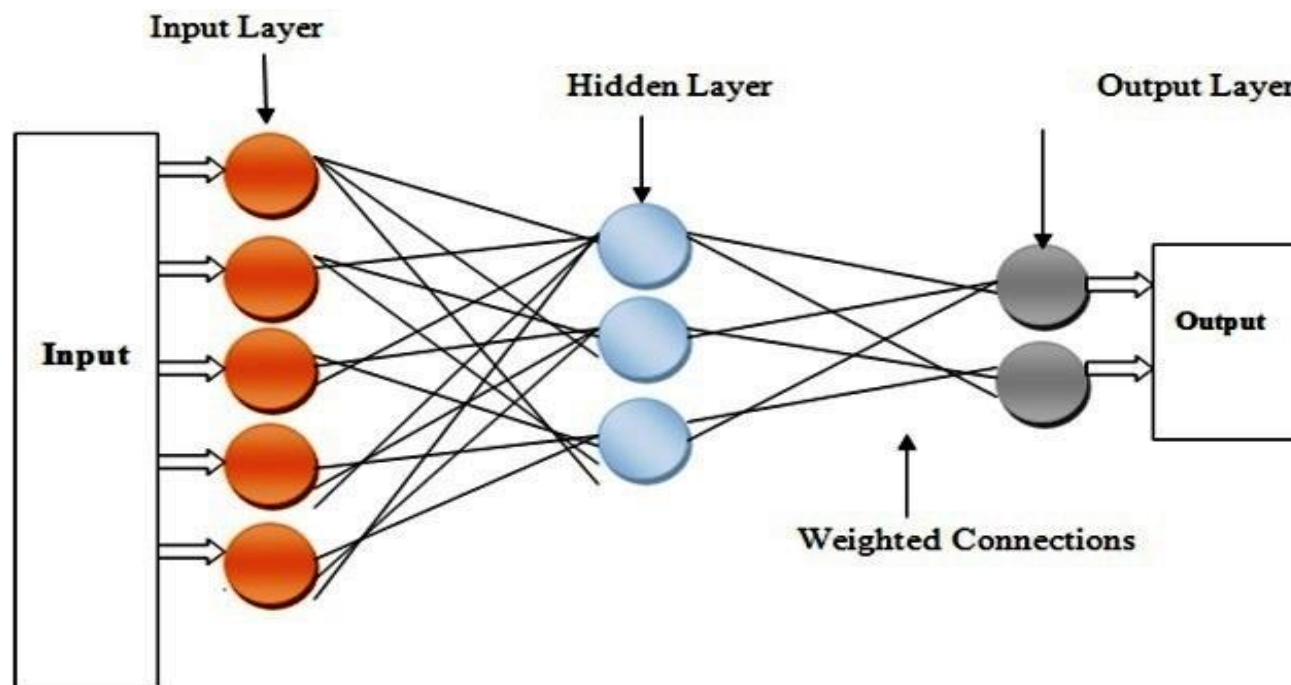
The main objective of this study is to classify and predict the presence and absence of hypertension among people of Gujrat on the basis of significant independent variables. Target population was the visitors of Aziz Bhatti Shaheed Hospital Gujrat who visited Hospital for the period march 1st, to June 28th. A sample of 300 respondents was taken from where 150 cases and 150 controls were observed.

Data collected by interviewing the patients using well-designed questionnaire and checked their BP where cases considered as hypertension patients with (BP: $\geq 140/90$) and healthy controls (BP: $\leq 120/80$) were the hypertension patient's attendants who had family history of BP and their age matched with BP patients. Data was collected through purposive sampling and analyzed using SPSS-21. Chi-square was used to find the association between the hypertension (yes or no) and BMI (normal or over-weight), stress (yes or no), extra salt intake (yes or no), exercise (yes or no) and for the age categories.

Multi-layer Perceptron Artificial Neural Network (ANN) technique was used for the classification and prediction of hypertension. Three layers input layer, hidden layer and output layer holds by ANN and softmax activation function is appropriate.

A perceptron network including its three layers is illustrated in the following diagram

This network consists of 3 layers: input layer with five neurons, hidden layer with three neurons and one outer layer with two neurons. For categorical variables, $N-1$ neurons are used to represent N categories of variable.



RESULTS

In the present study, 150 Cases and 150 Control reported. Overall, 61.3% respondents were belongs to the joint family system and 38.7% belongs to nuclear family system, joint family may cause of hypertension due to high responsibility and mostly people of Gujrat married

about 74.3%, 20.0% were single, 2.3% divorced and 3.3% widow In a sample of 150 cases 45.3% were females and 54.7% were males and in controls 42% were females and 58% were males and most of the respondents belongs to the middle level of income between (40001Rs-60000Rs) and 72.7% cases had family history of BP and 72.0% for controls. For the cases: BMI reported as

10.7% Underweight, 54.0% normal weight, 22.7% overweight, and only 12.7 % were faced obesity. 40% were taking medication and 60% were not, and faced

high level of stress. Similarly for controls data are given in table1.

Table 1: Demographic characteristics (N=300).

Demographics		150 Cases (%)	150 Control (%)
Gender	Male	82 (54.7)	87(58.0)
	Female	68(45.3)	63 (42.0)
Monthly Family Income (Rs.)	<=20000	21(14.0)	30(20.0)
	20001-40000	21(14.0)	74(49.3)
	40001-60000	66(44.0)	30(20.0)
	60001-80000	35(23.3)	11(7.3)
	>=80001	7(4.7)	5(3.3)
Family history of BP	No	41(27.3)	42(28.0)
	Yes	109(72.7)	108(72.0)
Age (Years)	20-29	19(12.7)	19(12.7)
	30-39	48(32.0)	22(14.7)
	40-49	38(25.3)	30(20.0)
	>50	45(30)	79(52.0)
Body Mass Index (BMI)	Underweight	16(10.7)	1(0.7)
	Normal weight	81(54.0)	5(3.3)
	Over weight	34(22.7)	70(46.7)
	Obesity	19(12.7)	74(49.3)
Medication	No	90(60.0)	111(74.0)
	Yes	60(40.0)	39 (26.0)
Stress	No	14(9.3)	51(34.0)
	Yes	136(90.7)	99(66.0)
Diabetes	No	71(47.3)	72(48.0)
	Yes	79(52.7)	78(52.0)
Take salt restricted diet	No	76(50.7)	60(40.0)
	Yes	74(49.3)	90(60.0)
Take exercise	No	38(25.3)	53(35.3)
	Yes	112(74.7)	97(64.7)

Chi square test of association shows significant relationship between hypertension and its associated risk factors i.e. age, BMI, stress taking salt intake and exercise. The people of Gujrat have high risk of hypertension is 5.004 (95% C-I 2.624 to 9.544) times more who are taking stress than those who are not. Those who are taking extra salt in their diet is having 1.541 (95% C-I 0.975 to 2.434) times more hypertension for the people who are not taking. The person who doesn't not take exercise having risk of hypertension is 0.621 (95% C-I 0.378 to 1.021) times more than who are taking daily exercise. Older age >55 years having BMI ≥15 taking extra salt intake in diet beings stressed are associated with hypertension [13] [14].

In ANN, hypertension was taken as dependent variable and stress, BMI where Body Mass Index categories were done according to the classification recommended for Asians BMI. Categories were <18.5 kg/m² as underweight, (18.5-24.9) kg/m² as normal, (25-29.9) kg/m² as overweight and BMI of 30 or greater as

obesity, family history, and some demographics such as age, extra salt consumption, lack of physical activity and family income were taken as independent variables. In partitioning of sample size, training samples based on 208 patients while testing samples were based on 92 patients. ANN contains 20 units in input layer, 6 units in hidden layer and 2 units in output layer. As an activation function, Softmax function was used from hidden to output layer in the model.

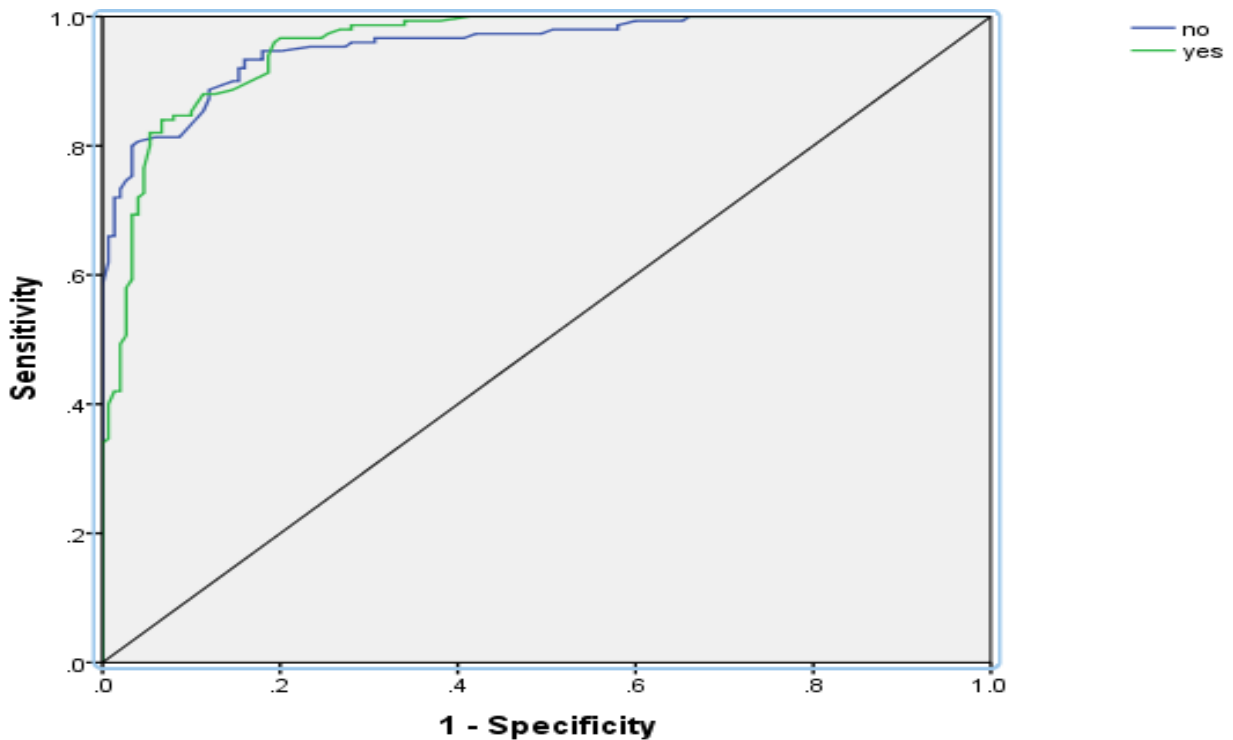
Table 2 showed the classification results for the respondents to be hypertensive. Results showed the correct and incorrect classification for both training and testing samples. Main diagonal cell showed the correct classification while off-diagonal cell showed incorrect classification. In training sample, due to independent variables non-hypertensives were correctly classified in its own category by 93.2% and 8.6% incorrect classified in another category. While hypertensives were correctly classified (85.7%) in its own category and misclassified (14.3%) in another category. Therefore, overall correct classification in training sample was 89.4% and in testing

sample was 82.6%. This model showed good classification in both categories (hypertension and non-hypertension) due to independent variables.

In Figure 2, the area under the ROC curve is greater than 0.90 % which provides that model is good fit.

Table 2: Classification of hypertension

Sample	Observed	Predicted		Correct (%)
		Non-hypertension	Hypertension	
Training	Non-hypertension	96	7	93.2%
	Hypertension	15	90	85.7%
	Overall Percent	53.4%	46.6%	89.4%
Testing	Non-hypertension	39	8	83.0%
	Hypertension	8	37	82.2%
	Overall Percent	51.1%	48.9%	82.6%



Dependent Variable: have you any blood pressure issue

Figure-2: ROC Curve by ANN model

Figure 3: represents the significance of independent variables to predict the chance for a person to be hypertensive. An ANN model gave highest importance to the BMI as it fully participated (100%) in classification of hypertension, BMI was the highest risk factor of hypertensive [13]. Monthly family income was the second important variable with 98.2%. Third and

fourth important variables were age and stress with 52.4% and 41.8% participation respectively. Extra salt consumption was the fifth important variable with 39.0% participation in classification of hypertension among individuals. Least important variable was family history with 23.1%.

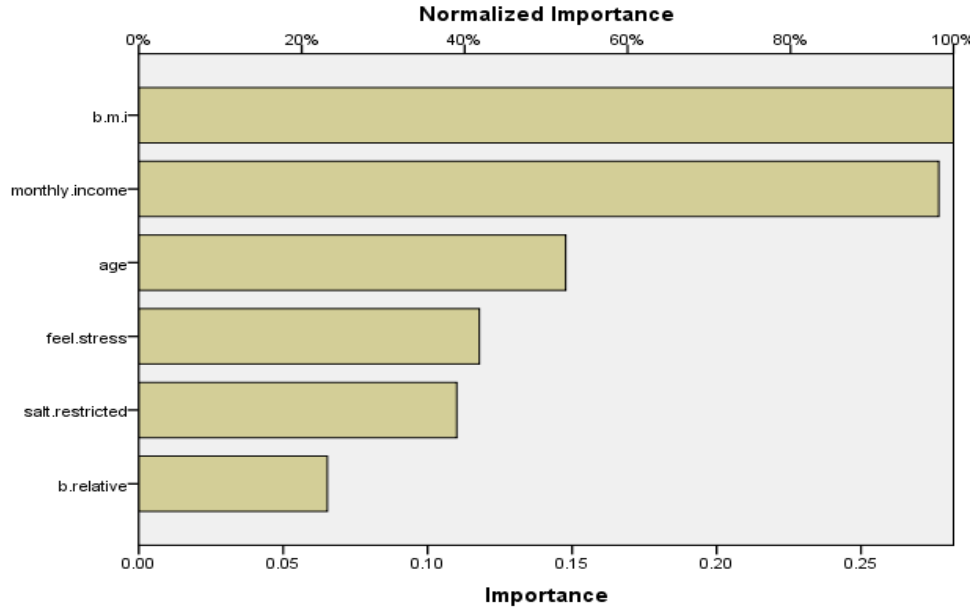


Figure-3: Importance of independent variables

Prediction by ANN model: Artificial Neural Network model can be used to predict the chances for the individual to be hypertensive taking prediction weights and relationships. Here, prediction for cases and controls were checked.

The responses of one respondent in control group are as: respondent was non-hypertensive, age of category 50-59 years, BMI, middle class family, had family history of hypertension, stress and salt consumption.

The independent variable denoted by x_i , w_{ij} weights of i^{th} independent variable and y_j is calculated by x_i , and w_{ij} as given below:

$$j_i = bias + \sum_{j=1} w_{ij}x_i \quad i = 1, 2, \dots, n$$

The computed values on the base of observed information are as:

$$\begin{aligned} y_1 &= -0.442 & y_2 &= -4.913 \\ y_3 &= -3.408 \\ y_4 &= 2.571 & y_5 &= 3.298 \\ y_6 &= -2.725 \end{aligned}$$

softmax function is used in ANN to obtain the predicted probability for classification. Mathematically softmax function can be written as:

$$\gamma(z_k) = \frac{e^{z_k}}{\sum_j e^{z_j}}$$

Where,

$$z_2 = bias + \sum_{j=1}^2 w_{i2} \tanh(y_j)$$

and $\tanh(y_j)$ is the hyperbolic tangent function of the calculated values of y_i

The calculated values for z_k are -0.8409 and 3.14277, these were used in softmax function for prediction. Predicted probability for the person to be hypertensive or non-hypertensive, are 0.98 and 0.018 respectively.

The responses of one respondent in case group with the age category 50-59 years, with normal weight, belong to lower middle class, having a family history of high BP issue, take stress and take less amount salt will have 98% chance to be hypertensive and 1% chance to be non-hypertensive.

DISCUSSION

Hypertension is known as raised blood pressure in medical terms. According to WHO report 2015 every one in four men and one in five women had high blood pressure.³ Different studies have been done on prevalence of hypertension and its risk factors. In this present study 300 patients with age 20 years and greater than 20 years. Results showed that prevalence of hypertension is higher in males (54.7%) than female (45.3%) in Aziz Bhatti Shaheed Hospital Gujrat.

Study explored that most of the hypertensive patients had symptoms of severe headache, blood in urine, stomach pain, difficulty in breathing, vomiting, blurred vision and nosebleeds. Results of this study clearly revealed that vomiting, severe headache and stomach pain were the most significant symptoms of hypertension. These results were consistent with [4] [5]. In addition, an ANN model suggested, BMI was the most important contributor of hypertension [15] [16] [17]. Furthermore, hypertensive patients had diabetes (52.7%) and consumed excessive amount of salt in their diet.

Overweight and taking too much salt are major risk factors of hypertension [18]. Income was second most important contributor 98.2% by an ANN causes the hypertension [16]. Family history of high blood pressure was another risk factor of hypertension, (72.3%) of patients had family history of high blood pressure of which 60% of patients were taking medicine to control blood pressure while 40% were not taking any medication to control blood pressure [17].

In present study mostly age of patients were between 30-39 years. Age was the most important risk factor of hypertension [19] [20] [21] [22] and recently risk of hypertension is increased in younger age [15]. High blood pressure was common in the people age 50 or above years [10]. Stress was found to be the fourth significant factor of hypertension by ANN model and it was also consider the risk factor of CVD [12].

Conclusion: The results of this study concluded that more prevalence of hypertension is observed in males as compared to females. Family history, family income, age, BMI, stress and extra salt intake were found to most significant risk factors of hypertension. In addition, most common symptoms that were found in hypertensive patients were severe headache, stomach pain and nausea. ANN Model showed good classification for both hypertensives and non-hypertensives due to independent variables. BMI and family income are the most important contributors that played a major role in causing hypertension. Being aged is also proved to be an independent risk factor for hypertension. The basic infrastructure of health care system is not so much developed in many developing countries. So, there is urgent need to give awareness to patients at primarily stage, so that they may maintain their health status and risks of hypertension can be reduced.

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