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## Statistical study of reported cases of hypertensive patients at Akulue Memorial hospital, Nsukka, Enugu state

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### Abstract

Hypertension arises when the blood pressure against the artery walls is very high. Blood pressure is represented with two numbers. The first number (systolic) signifies the pressure in blood vessels when the heart beats and while second number (diastolic) denotes the pressure in the vessels when the heart rests between beats. Usually hypertension is referred to as blood pressure above 130/90, and is considered severe if the pressure is above 180/120.

Hypertension has been a major public health challenge in the world at large which is also the most common widespread of diseases affecting human life. Hypertension has been an important area of research due to its high prevalence and major risk factors for cardiovascular diseases. It affects mostly adults and is called a silent killer because it shows no symptom. This article examines reported cases of hypertensive patients at Akulue Memorial Hospital, Nsukka, Enugu State. The data used in this research was collected from inpatient unit of the above mentioned hospital for a period of ten years, from 2009 to 2018. A 3-way contingency table was used based on Chi-squared test of independency. The result obtained from this study show that there is an association between the three criteria tested (gender, year and type of hypertension patient suffers). Also, we observed that the type of hypertension a patient suffers from depends on gender and year of occurrence.

**Keywords:** hypertension, contingency table, chi-square test

### 1. Introduction

Hypertension also known as high blood pressure is a worldwide problem that affects approximately 15-20% of all adults. Hypertension is a silent killer as it shows no symptom, it is simple to diagnose and usually can be controlled by healthy diet, regular exercise, medication prescribed by doctors or a combination of these, untreated hypertension will cause serious health condition <sup>[1]</sup>. Hypertension affects the structures and functions of small muscular arteries and other blood vessels and can cause damage to some organ in the body like kidney, brain and eye, related with the end stage of renal disease and to be the cause of stroke. Various antihypertensive drugs such as beta-blocking agents, hypotensive diuretics, calcium antagonist, angiotensin converting enzyme inhibitors (ACEI), angiotensin II receptor antagonists and alpha-receptor blocking agents were usually used to control hypertension. Two or more antihypertensive drugs from different categories can also be combined to achieve optimal results as the efficacy of these drugs is only about 40-60%. There are two types of hypertension, primary and secondary hypertension. Primary hypertension is a heterogeneous disorder as different patients have different factors that cause high blood pressure <sup>[2]</sup>. The cause of primary hypertension is still unknown but it is considered as the sum of interaction between genetic, environmental factors and life style <sup>[3]</sup>. Lifestyle factors include smoking, drinking too much alcohol, stress, being overweight, eating too much salt, and not getting enough exercise can also contribute to it. Secondary hypertension is when there's an identifiable and potentially reversible cause of your hypertension.

Most adults with hypertension are in this category. Despite years of research on hypertension, a specific cause isn't known. Only about 5 to 10 percent of hypertension is the secondary type. It's more prevalent in younger people. The underlying causes of secondary hypertension include: narrowing of the arteries that supply blood to your kidneys, adrenal gland disease and hormone abnormalities.

In 2017, the American College of Cardiology/American Heart Association issued new consensus guidelines that included a controversial redefinition of hypertension. Although the number of adults with uncontrolled hypertension has improved, challenges in control persist, especially for those between the ages of 18-39 years and for those older than 75 years of age <sup>[4]</sup>. The chart below gives more information show different blood pressure reading.

### 1.1. Statement of Problem

Due to high mortality rate among hypertensive patients in the world of which 12 million patients dies every year especially from developing countries with high prevalence in adult which is worrisome calls for urgent measures to arrest the situation <sup>[5]</sup>.

<b>Blood Pressure Stages</b>			
<b>Blood Pressure Category</b>	<b>Systolic mm Hg (upper #)</b>		<b>Diastolic mm Hg (lower #)</b>
<b>Normal</b>	<b>less than 120</b>	<b>and</b>	<b>less than 80</b>
<b>Elevated</b>	<b>120-129</b>	<b>and</b>	<b>less than 80</b>
<b>High Blood Pressure (Hypertension) Stage 1</b>	<b>130-139</b>	<b>or</b>	<b>80-89</b>
<b>High Blood Pressure (Hypertension) Stage 2</b>	<b>140 or higher</b>	<b>or</b>	<b>90 or higher</b>
<b>Hypertensive Crisis (Seek Emergency Care)</b>	<b>higher than 180</b>	<b>and/or</b>	<b>higher than 120</b>

Source: American Heart Association

**Fig 1:** Blood Pressure Stages

### 1.2. Objective of the Study

The objective of the study is to examine if the prevalence of hypertension is dependent on gender, year and the type of hypertension a patient suffers from.

### 1.3. Scope of the Study

In this research, Akule Memorial Hospital is used as a case study, the study covers reported cases of hypertensive patients in the hospital from 2009-2018.

## 2. Literature Review

Many research works have been conducted on reported hypertension cases in most of the African countries of which Nigeria is involved.

Using two ways CATANOVA of reported death cases at the Good Shepherd Specialist Hospital Uwani, Enugu The result of the study shows that patients above 60 years died more in the hospital and there were relatively low infant deaths within the period under study <sup>[6]</sup>.

An analysis of high blood pressure with respect to demographic factors" used ordinal logistic regression as the tool, data of 1,966 patients were obtained and the result showed that only age is statistically significant of the three demographic factors used age, sex and status(alive or dead) of some patients <sup>[7]</sup>.

Using Kruskal Wallis test, sign test and test of goodness-of-fit test on an analysis of incidence of hypertension pandemic in Nigeria, the null hypothesis of the first two tests was rejected while the third was accepted which he concluded that there is rise in the reported cases of hypertension in Nigeria <sup>[8]</sup>.

Using chi-square test to test statistical analysis of admitted typhoid fever patients, the data was collected from in-patients of Bishop Shannahan Hospital, Nsukka. It was found out that stay of typhoid fever patients is independent of gender but it depends on type of typhoid, age and the doctor that attended to the patients <sup>[9]</sup>.

Hypertension in Ferlo (Northern Senegal) on a population of 500 individuals, a quota sampling method was used to reveal that a widespread of hypertension increased with age and they concluded that a strategic approach must be employed to prevent and control hypertension <sup>[10]</sup>.

Hypertension affects the structures and functions of small muscular arteries, arterioles and other blood vessels and can cause damage to some organ in the body like kidney, brain and eye, related with the end stage of renal disease and to be the cause of stroke <sup>[11]</sup>.

This review discusses the magnitude of the problem, its epidemiology, and the evaluation and management of hypertension as recommended by the reports of the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure. Activities related to the control of this disorder are also highlighted. Data from the Third National Health and Nutrition Examination Survey, 1998-1994, (NHANESIII) suggest approximately three-quarters (75%) of Black hypertensive are aware of

their diagnosis, but only 57% are treated and just 25% have their blood pressure under control (<140 mm Hg systolic and <90 mm Hg diastolic). Although substantial evidence indicates a significant increase in awareness of hypertension over the past three decades, control rates are remarkably low, particularly among Blacks. This review serves to emphasize and reiterate the burden of hypertension among Blacks and acts as a reminder of the need for additional research to determine if culturally competent interventions are appropriate to prevent, treat, and control this disease within this population [12]

**3. Collection and Presentation of Data**

The data used in this study was collected from in-patient record of Akulue Memorial Hospital, Nsukka, Enugu State from 2009-2018. 3-way contingency table was used in analyzing the data. 3- way contingency table is a 2-way contingency table with additional third variable in the cross-classification table. It provides some insight into the structure of the data which are not easily perceived if the data were analyzed using 2-way contingency table of nominal chi-square

**Table 1:** Data Layout for 3-Way Contingency Table.

	Y <sub>1</sub>			Y <sub>2</sub>			
	Z <sub>1</sub>	Z <sub>2</sub>	n <sub>+j+</sub>	Z <sub>1</sub>	Z <sub>2</sub>	n <sub>+j+</sub>	
X <sub>1</sub>	n <sub>111</sub>	n <sub>112</sub>	n <sub>11+</sub>	n <sub>121</sub>	n <sub>122</sub>	n <sub>12+</sub>	n <sub>1++</sub>
X <sub>2</sub>	n <sub>211</sub>	n <sub>212</sub>	n <sub>21+</sub>	n <sub>221</sub>	n <sub>222</sub>	n <sub>22+</sub>	n <sub>2++</sub>
n <sub>+k</sub>	n <sub>+11</sub>	n <sub>+12</sub>	n <sub>+1+</sub>	n <sub>+21</sub>	n <sub>+22</sub>	n <sub>+2+</sub>	n

Where,  $n = \sum_i \sum_j \sum_k n_{ijk}$ ,  $n_{+j+} = \sum_i \sum_k n_{ijk}$ ,  $n_{+k} = \sum_i \sum_j n_{ijk}$  and  $n_{i++} = \sum_j \sum_k n_{ijk}$

There are Four Hypotheses that will be tested in using 3-Way Contingency table.

One, test whether there is independency in three variables that is

H<sub>0</sub>:  $\pi_{ijk} = P(\pi_{i++} \pi_{+j+} \pi_{+k}) = P(\pi_{i++})P(\pi_{+j+}) P(\pi_{+k})$  (there is no association between the three variables).

H<sub>1</sub>:  $\pi_{ijk} = P(\pi_{i++} \pi_{+j+} \pi_{+k}) \neq P(\pi_{i++})P(\pi_{+j+})P(\pi_{+k})$  (there is association between the three variables).

Test Statistic

$$\chi^2_{cal} = \sum_i \sum_j \sum_k \frac{(n_{ijk} - f_{ijk})^2}{f_{ijk}} \sim \chi^2_{ijk - (i+j+k) + 2} \tag{1}$$

Where

i = number of variables in X (gender), j = number of variables in Y (year)

k = number of variables in Z (type of hypertension)

$n_{ijk}$  is the observed frequency in  $ijk$ ,  $f_{ijk}$  is the estimated expected frequency in  $ijk$

$$f_{ijk} = n \binom{n_{i++}}{n} \binom{n_{+j+}}{n} \binom{n_{+k}}{n} \tag{2}$$

Decision Rule: *Reject H<sub>0</sub> if  $\chi^2_{cal} > \chi^2_{tab}$  otherwise accept it.*

Two, test for conditional independency in the contingency table. We may test whether anyone of the three variables is dependent of the other two that is, we may need to test whether the X variable is independent of Y and Z variables or Y variable is independent of X and Z variables or Z variable is independent of X and Y variables. The hypothesis can be stated as follows;

H<sub>0</sub>:  $\pi_{ijk} = P(\pi_{i++})P(\pi_{+j+} \pi_{+k})$  (X variable is independent of Y and Z variables).

H<sub>1</sub>:  $\pi_{ijk} \neq P(\pi_{i++})P(\pi_{+j+} \pi_{+k})$  (X variable is dependent of Y and Z variables).

Test Statistic  $\chi^2_{cal} = \sum_i \sum_j \sum_k \frac{(n_{ijk} - f_{ijk})^2}{f_{ijk}} \sim \chi^2_{(i-1)(jk-1)}$

$$f_{ijk} = n \binom{n_{i++}}{n} \binom{n_{+jk}}{n} \tag{3}$$

Decision Rule: *Reject H<sub>0</sub> if  $\chi^2_{cal} > \chi^2_{tab}$  otherwise accept it.*

Similar procedure can be used for testing the remaining two. 3-way contingency table is used to test for the independency of gender, the type of hypertension and year and as well test whether gender is independent of the type of hypertension and year from the data collected from Akulue Memorial Hospital, Nsukka.

**Table 2:** 3-Way Contingency Table Showing Year, Gender and type of Hypertension Patient suffers from 2009 through 2018.

Year	2009		Total
Gender	Primary Hypertension	Secondary Hypertension	N <sub>+J+</sub>
Male	114	89	203
Female	73	139	212
N <sub>+K</sub>	187	223	415

Year	2010		Total
Gender	Primary Hypertension	Secondary Hypertension	N <sub>+J+</sub>
Male	94	98	192
Female	196	86	282
N <sub>++K</sub>	290	184	474

Year	2011		Total
Gender	Primary Hypertension	Secondary Hypertension	N <sub>+J+</sub>
Male	109	88	197
Female	38	84	122
N <sub>++K</sub>	147	172	319

Year	2012		Total
Gender	Primary Hypertension	Secondary Hypertension	N <sub>+J+</sub>
Male	199	113	312
Female	110	98	208
N <sub>++K</sub>	309	211	520

Year	2013		Total
Gender	Primary Hypertension	Secondary Hypertension	N <sub>+J+</sub>
Male	72	116	188
Female	120	123	243
N <sub>++K</sub>	192	239	431

Year	2014		Total
Gender	Primary Hypertension	Secondary Hypertension	N <sub>+J+</sub>
Male	180	43	223
Female	80	71	151
N <sub>++K</sub>	260	114	374

Year	2015		Total
Gender	Primary Hypertension	Secondary Hypertension	N <sub>+J+</sub>
Male	70	62	132
Female	125	60	185
N <sub>++K</sub>	195	122	317

Year	2016		Total
Gender	Primary Hypertension	Secondary Hypertension	N <sub>+J+</sub>
Male	115	67	182
Female	90	78	168
N <sub>++K</sub>	205	145	350

Year	2017		Total
Gender	Primary Hypertension	Secondary Hypertension	N <sub>+J+</sub>
Male	112	60	172
Female	165	45	210
N <sub>++K</sub>	277	105	382

Year	2018		Total
Gender	Primary Hypertension	Secondary Hypertension	N <sub>+J+</sub>
Male	178	41	219
Female	62	56	118
N <sub>++K</sub>	240	97	337

Let X<sub>i</sub> represent gender, i = 1,2

Y<sub>j</sub> represent year, j = 2009, 2010, ..., 2018

Z<sub>k</sub> represent the type of hypertension, k = 1,2

$$n_{+j+} = \sum_i \sum_k n_{ijk} \tag{4}$$

$$n_{+1+} = 187+223 = 415, n_{+2+} = 290+184 = 474, n_{+3+} = 147+172 = 319, n_{+4+} = 309+211 = 520,$$

$$n_{+5+} = 192+239 = 431, n_{+6+} = 260+114=374, n_{+7+} = 195+122=317, n_{+8+} = 205+145=350$$

$$n_{+9+} = 277+105=382, n_{+10+} = 240+97=337$$

$$n_{++k} = \sum_i \sum_j n_{ijk} \tag{5}$$

$$n_{++1} = 187+290+147+309+192+260+195+205+277+240=2302$$

$$n_{++2} = 223+184+172+211+239+114+60+78+45+56= 1612$$

$$n_{i++} = \sum_j \sum_k n_{ijk} \tag{6}$$

$$n_{1++} = 203+192+197+312+188+223+132+182+172+219 = 2020$$

$$n_{2++} = 212+282+122+208+243+151+185+168+210+118= 1899$$

Test of the Independency of Gender, the type of Hypertension and Year.

H<sub>0</sub>:  $\pi_{ijk} = P(\pi_{i++} n \pi_{+j+} n \pi_{++k}) = P(\pi_{i++}) P(\pi_{+j+}) P(\pi_{++k})$  (there is no association between the three variables).

H<sub>1</sub>:  $\pi_{ijk} = P(\pi_{i++} n \pi_{+j+} n \pi_{++k}) \neq P(\pi_{i++}) P(\pi_{+j+}) P(\pi_{++k})$  (there is association between the three variables).

$\alpha = 0.05$

Test Statistic

$$\chi^2_{cal} = \sum_i \sum_j \sum_k \frac{(n_{ijk} - f_{ijk})^2}{f_{ijk}} \sim \chi^2_{ijk - (i+j+k)+2} \quad (7)$$

Where i = number of variables in X (gender)

j = number of variables in Y (year)

k = number of variables in Z (type of hypertension)

$n_{ijk}$  is the observed frequency in ijk

$f_{ijk}$  is the estimated expected frequency in ijk

$$f_{ijk} = n \binom{n_{i++}}{n} \binom{n_{+j+}}{n} \binom{n_{++k}}{n} \quad (8)$$

**Table 3:** Calculated observed and estimated expected frequencies.

Cell	Observed Frequencies ( $n_{ijk}$ )	Estimated Expected Frequencies ( $f_{ijk}$ )	$\frac{(n_{ijk} - f_{ijk})^2}{f_{ijk}}$
$f_{1,1,1}$	114	125.66	1.08
$f_{1,1,2}$	89	87.99	0.01
$f_{1,2,1}$	73	143.51	34.64
$f_{1,2,2}$	139	100.49	14.76
$f_{1,3,1}$	94	96.58	0.07
$f_{1,3,2}$	98	67.63	13.63
$f_{1,4,1}$	196	157.44	9.44
$f_{1,4,2}$	86	110.25	5.33
$f_{1,5,1}$	109	130.49	3.54
$f_{1,5,2}$	88	91.38	0.13
$f_{1,6,1}$	38	113.23	49.98
$f_{1,6,2}$	84	79.29	0.28
$f_{1,7,1}$	199	95.98	110.58
$f_{1,7,2}$	113	67.21	31.20
$f_{1,8,1}$	110	105.97	0.15
$f_{1,8,2}$	98	74.21	7.63
$f_{1,9,1}$	72	115.66	16.48
$f_{1,9,2}$	116	80.99	15.13
$f_{1,10,1}$	120	102.03	3.16
$f_{1,10,2}$	123	71.45	37.19
$f_{2,1,1}$	180	118.121	32.42
$f_{2,1,2}$	43	82.72	19.07
$f_{2,2,1}$	80	134.91	22.35
$f_{2,2,2}$	71	94.48	5.84
$f_{2,3,1}$	70	90.80	4.76
$f_{2,3,2}$	62	63.58	0.04
$f_{2,4,1}$	125	148.01	3.58
$f_{2,4,2}$	60	103.64	18.38
$f_{2,5,1}$	115	122.68	0.48
$f_{2,5,2}$	67	85.91	4.16
$f_{2,6,1}$	90	106.45	2.54
$f_{2,6,2}$	78	74.54	0.16
$f_{2,7,1}$	112	90.23	5.25
$f_{2,7,2}$	60	63.18	0.16
$f_{2,8,1}$	165	99.62	42.91
$f_{2,8,2}$	45	69.76	8.79
$f_{2,9,1}$	178	108.73	44.13
$f_{2,9,2}$	41	76.14	16.22
$f_{2,10,1}$	62	95.92	12
$f_{2,10,2}$	56	67.17	1.86
TOTAL			594.11

$$\chi_{cal}^2 = \sum_i \sum_j \sum_k \frac{(n_{ijk} - f_{ijk})^2}{f_{ijk}} = 594.11$$

$$\chi_{ijk-(i+j+k)+2}^2 = 43.77$$

Decision Rule: *Reject*  $H_0$  if  $\chi_{cal}^2 > \chi_{tab}^2$  otherwise accept it.

Since  $\chi_{cal}^2 = 594.11 > \chi_{tab}^2 = 43.77$ , we reject  $H_0$  and conclude that there is association between the three variables.

Test to ascertain whether the prevalence of hypertension is independent of gender and year of occurrence.

$H_0$ :  $\pi_{ijk} = P(\pi_{++k})P(\pi_{i++})P(\pi_{+j+})$  (prevalence of hypertension is independent of gender and year)

$H_1$ :  $\pi_{ijk} \neq P(\pi_{++k})P(\pi_{i++})P(\pi_{+j+})$  (prevalence of hypertension is dependent of gender and year).  $\alpha = 0.05$

Test Statistic

$$\chi_{cal}^2 = \sum_i \sum_j \sum_k \frac{(n_{ijk} - f_{ijk})^2}{f_{ijk}} \sim \chi_{(k-1)(j_i-1)}^2$$

Where

$$f_{ijk} = n \left( \frac{n_{++k}}{n} \right) \left( \frac{n_{i++}}{n} \right) \chi_{cal}^2 = \sum_i \sum_j \sum_k \frac{(n_{ijk} - f_{ijk})^2}{f_{ijk}} = 957.47$$

$$\chi_{(i-1)(jk-1)}^2 = \chi_{(2-1)((10)(2)-1)}^2 = 30.14$$

Decision Rule: *Reject*  $H_0$  if  $\chi_{cal}^2 > \chi_{tab}^2$  otherwise accept it.

Conclusion: since  $\chi_{cal}^2 = 957.47 > \chi_{tab}^2 = 30.14$ , we reject  $H_0$  and conclude that hypertension is dependent of gender and year.

#### 4. Summary

Hypertension has been a major public health challenge and important area of research due to its high prevalence and major risk factors for cardiovascular diseases. Data was collected from Akulue Memorial Hospital Nsukka, Enugu State; the data were presented according to the male and female attendance over the years from 2009 to 2018. Analysis was carried out on the data and the methodology used for the analysis is 3-way contingency table. The result of the work shows that year of infection, gender of the patient and the type of hypertension a patient suffers from are dependent (they all associate with each other). Also, from the result of the second test, we observed that hypertension is dependent on year of occurrence and gender of the patient.

#### 5. Conclusion

From the result obtained in this work, we found out that the type of hypertension, year and gender has an association (interaction). Also, hypertension whether primary or secondary hypertension is dependent on the gender and year.

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