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A Mathematical Model for Estimating the Blood Pressure of Human Beings Using Some Anthropometric Parameters

Ogwumu Onah David[1, *], Ajimoti Adam[2], Anyanwu Emeka Odinaka[1], Eguda Felix Yakubu[3], Okorie Charity Ebelechukwu[1], Afolabi Oluseun Ahmed[2], Otti Emeka Emmanuel[1]

[1]Department of Mathematics and Statistics, Federal University Wukari, Wukari, Nigeria
[2]Department of Mathematics, University of Ilorin, Ilorin, Nigeria
[3]Department of Mathematics, Federal University Dutse, Dutse, Nigeria

Email address

onahdavid2010@gmail.com (O. O. David)
[*]Corresponding author

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Abstract: In this study a model for estimating the blood pressure of humans was developed in relation to a person's age, weight, pulse rate and body temperature parameters. The model was optimized to determine the nature of the extreme value of the Blood Pressure model and whether humans could have a maximum or minimum value for blood pressure. However, the optimization result showed that there is no specific human blood pressure value that could be called a maximum or minimum. Furthermore, the model's resulting data was correlated with the measured/gathered data and the outcome of the correlation analysis showed a very high correlation of about 80% between the two results which therefore recommends as a standard measure for human's Blood pressure.

Keywords: Human Bp, Optimization, Anthropometric Measurement, Mathematical Model, Age, Weight, Pulse Rate Parameter, Body Temperature Parameter

1. Introduction

Estimating Human Bp is so important in every country today. Many disease conditions make it impossible to control patient's Bp. This anthropometric measurement is essential to calculate medicament dose and doses. [7] Says, an anthropometric measure is the single most universally applicable, inexpensive and non-invasive method available for the assessment of size, proportion and composition of human body. Thus, it would also be important to discuss in the cause of this work various mathematical approaches to estimate BP already used worldwide and a mathematical look at this anthropometric measurement in particular, is essential.

Cardiovascular disease is the leading cause of death and disability world-wide. Blood pressure, throughout the range seen in developed countries, is the most important risk factor for cardiovascular disease. [6] Defines Blood pressure (Bp as will be use in this context) as the pressure exerted by circulating blood upon the walls of blood vessels. BP is also refers to the arterial pressure in the systemic circulation. Bp is usually expressed in terms of the systolic (maximum) or high blood pressure HBp over diastolic (minimum) low blood pressure LBp and is measured in millimetres of mercury (mm Hg). Lowering Bp within the whole population by lifestyle interventions, such as reducing dietary salt intake and increasing the consumption of fruit and vegetables, will be of great benefit. Blood pressure-lowering trials also demonstrate immense benefits in preventing strokes, heart failure and coronary heart disease.

High blood Pressure (HBp) also refers to as hypertension is a serious condition that affects adults today. It is called the "silent killer" because people often have no symptoms, yet it can lead to some serious and sometimes even fatal conditions. HBp forces the heart to work harder, which can make it grow weaker. The effect can be felt throughout the body

Meanwhile, we need to employ the knowledge of mathematical modelling for this task in our hands because; mathematical modelling is the aspects of mathematics that connects the learning of its principles, concepts and procedures to the real world phenomena.

According to [1], mathematical models are useful experimental tools for building and testing theories, accessing quantitative conjectures, answering specific questions, determining sensitivities to changes in parameter values and estimating key parameters from data. But, [2] advised that the closer mathematical model assumptions are to reality of dynamics, the more difficult the mathematical analysis, hence the need to simplify assumptions without losing track of the situation or dynamics at hand.

1.1. Relevance of the Study

The study of Bp of human beings is important to enable one know when he is becoming/about to be hypertensive or hypotensive, so as to be able take all necessary dietary and regular exercise precautions.

Secondly, the study is also useful for one to identify whether he is or will soon be vulnerable to some cardiovascular diseases or not.

Also, since mathematical modelling is useful for proper medication dosage [4] then; this mathematical model for BP of people developed in this research work could be instrumental for deciding the proper medication dosage and nutritional evaluation for a patient based on estimated BP. This model is especially useful in many of the remote interior settings in the world, in which a reliable sphygmomanometer, a device used for measuring arterial pressure or BP is not easily available, because of financial or transport issues etc.

Also, in a war or crisis situation in where which the wounded soldiers or citizen's Bp need to be checked but there is no reliable sphygmomanometer, the doctors' or nurses can use this mathematical model with its parameter at hand tocheck the war victims Bp.

1.2. Relevance of the Study over Others

The study is peculiar to a certain geographical area in Nigeria and can be adopted for use in other areas with similar characteristics of human beings.

As an addendum, without a sphygmomanometer (which sometimes may be expensive) either in hospital or at home of rural areas, if an individual could identify his weight, temperature and pulse rate, he could as well estimate his BP using the model developed in this work.

2. Methodology

Under this section, we shall consider the following subheadings like: Formulation of the model itself, Basic assumptions needed to give us a model that conforms to reality, establish a relationship between our model parameters, and evaluate the resulting model equations' constants.

2.1. Formulation of the Model

In similar, this section will also address the following subtopics as they unfold.

2.1.1. Basic Assumptions

(i). Blood Pressure Versus Age

Theoretically, a human of 45 years of age is assumed to have a higher BP than a human of 18 years of age, but experimentally BP does not always increase as age increases. For example, an 18yrs old individual that weighs above 100kg or obese has more HBp than an individual of 45yrs of age that is on dietary or weighs less than 70kg. So, for this research, we were able to conclude that age affects Bp. So therefore, older individual are prone to high Bp than younger individuals. And thus, as human age increases, its Bp tends to increase (in the absence of any control measures).

Hence mathematically,

$$\left.\begin{aligned} Bp &\propto A \\ Bp &= k_1 A \end{aligned}\right\} \tag{1}$$

(ii). Blood Pressure Versus Body Temperature

Fluctuation in body temperature is also one ofthe factors that cause high blood pressure or low blood pressure as the case may be. So, how exactly does body temperature affect bloodpressure? Let us know how. When a person is exposed to heat or hightemperature, he sweats profusely, leading todehydration. Dehydration reduces the volume ofblood, which also results in falling of the bloodpressure. Secondly, people suffering from anyillness where fever is one of the symptoms, experience rise in blood pressure, i.e., feverincreases the blood pressure. Why does this happen? During fever, the body temperatureincreases considerably, which in turn increasesthe heart rate. As the heart rate increases, theblood pressure also rises. Therefore, peoplesuffering from fever experience rise in bloodpressure. It suffices to remark that the Bp of a person is directly proportional to its body temperature since any increase in one leads to a corresponding increase in the other. Hence mathematically,

$$\left.\begin{aligned} Bp &\propto T \\ Bp &= k_2 T \end{aligned}\right\} \tag{2}$$

(iii). Blood Pressure Versus Weight

A human being that is obese or weigh above 90kg tends to have HBp than a man of the same age with the other that weigh less will have a LBp. Thus this can be postulated that, Bp of a person is directly proportional to his weight since a decrease in one leads to a corresponding decrease in the other or vice versa.

Hence mathematically,

$$\left.\begin{aligned} Bp &\propto W \\ Bp &= k_3 W \end{aligned}\right\} \quad (3)$$

(iv). Blood Pressure Versus Temperature of the Environment

According to [5], "It has been observed thatblood pressure increases in cold climates (i.e., winter) and decreases in warmer climate orsummer. In winter, the blood vessels getconstricted in order to retain the body heat andmaintain a proper body temperature. However, when the blood vessels get constricted, pressure is exerted on the heart. The heart need to pumpharder in order to force the blood in all thearteries and veins. This increases the bloodpressure" Hence, because this research was taken from a particular environment where the environmental temperature was almost constant, this study tends to neglect the temperature parameter's effect for our Bp model.

(v). Blood Pressure Versus Pulse/Heart Rate

An expert in life sciences, [12] describes pulse as the mechanical pulse of blood flow through the capillaries caused by the contractions of the heart per minute i.e. the number of beats per minute (b/min). Pulse can be faster when you exercise, have a fever, or are under stress. Because high blood pressure causes tension and complicates cardiovascular normal activity, it may cause stress with your pulse activity. Meaning, the arteries experience resistance against the flow of the blood. The pulse rate calculates the number of times the heart beats per minute. The rate measurements indicate the heart rate, heart rhythm and the strength of your pulse. Therefore, high blood pressure slows down normal blood flow causing the arteries to demonstrate difficulty with expanding.

Your blood pressure responds differently to different types of activity. During any type of exercise or physical activity, the blood pressure reacts according to the intensity of the movement. Specifically, the pulse rate (heart rate) may fluctuate during static or dynamic exercises. It will be slower when you are resting. [11] Says; to calculate your heart rate, find your pulse in your inner wrist, about 2 inches down from your thumb. Count the number of times you feel the pulse against your index finger in one minute. (Or count for 15 seconds and multiply by 4). Another way is that you put your index finger about an inch or two from the centre of your neck to either side. Moreover [9] and [10] Says from observation that increased heart rate is a common feature in hypertensive patients (HBp patients) and elevated heart rate is associated with development of hypertension (or HBp). So increase in Bp increases heart rate and vice versa. Since pulse is a kind of mechanism use in checking someone's heart rate.

Hence, mathematically and medically speaking,

Pulse rate = Heart rate

$$\left.\begin{aligned} Bp &\propto P \\ Bp &= k_4 P \end{aligned}\right\} \quad (4)$$

2.1.2. First Establishment of Model Parameter Relationship

From our respective postulation above, adding equation (1), (2), (3) and (4) gives

$$\left.\begin{aligned} 4Bp &= k_1 A + k_2 T + k_3 W + k_4 P \\ Bp &= k_1' A + k_2' T + k_3' W + k_4' P \end{aligned}\right\} \quad (5)$$

Where: $k_1' = \frac{k_1}{4}$, $k_2' = \frac{k_2}{4}$, $k_3' = \frac{k_3}{4}$ and $k_4' = \frac{k_4}{4}$

Where: A = Age of individual

T = Body temperature of an individual

W = Weight of an individual

P = Pulse rate of an individual

2.1.3. Nature of Equation's Basic Assumption

Under this heading, the nature of equation view was given to the relationship that existed between the variables of the model. Hence, a graph was plotted for Bp, body temperature, weight, pulse rate and heart rate and considering equation (1), (2), (3) and (4) it can be observed also that:

The relationship between Bp and age (A) is a linear equation relationship.

$$\therefore Bp = z_1 A + C_1 \text{ (Where } C_1 \text{ is a constant)} \quad (6)$$

The relationship between Bp and body temperature (T) is a linear equation relationship.

$$\therefore Bp = z_2 T + C_2 \text{ (Where } C_2 \text{ is a constant)} \quad (7)$$

The relationship between Bp and weight (W) is a linear equation relationship.

$$\therefore Bp = z_3 W + C_3 \text{ (Where } C_3 \text{ is a constant)} \quad (8)$$

The relationship between Bp and pulse rate (P) is a linear equation relationship.

$$\therefore Bp = z_4 P + C_4 \text{ (Where } C_4 \text{ is a constant)} \quad (9)$$

2.1.4. Second Establishment of Model Parameter Relationship

From our respective equations above, adding equation (6), (7), (8) and (9) gives

$$Bp = z_1' A + z_2' T + z_3' W + z_4' P + C \quad (10)$$

Where C is a constant i.e. C = $(C_1+C_2+C_3C_4)$ /4

$$z_1' = \frac{z_1}{4}, z_2' = \frac{z_2}{4}, z_3' = \frac{z_3}{4} \text{ and } z_4' = \frac{z_4}{4}$$

2.1.5. General Establishment of Model Parameter Relationship

Form our respective postulation above, if we add equations (5) and (10) in a similar way, we have,

$$\left.\begin{aligned} 2Bp &= \left(k_1^{'} + z_1^{'}\right)A + \left(k_2^{'} + z_2^{'}\right)T + \left(k_3^{'} + z_3^{'}\right)W + \left(k_4^{'} + z_4^{'}\right)P + C \\ \therefore Bp &= \alpha A + \beta T + \gamma W + \lambda P + \delta \end{aligned}\right\} \tag{11}$$

Where: T = Body temperature of human being
W = Weight of human being
P = Pulse rate of human being
H = Heart rate of human being
α, β, γ, λ and δ are model constants of proportionality.

2.2. Analysis of the Model in Order to Evaluate Its Equation Constants

To evaluate the constants in the model above, equation (11) is going to be differentiated partially with respect to α β, γ and δ respectively. To do this, we have to minimize the model using least squares methodas follows: from (11) we let,

$$Z_{\min} = \min \sum \left(Bp_i - \alpha A_i - \beta T_i - \gamma W_i + \lambda P_i - \delta\right)^2 \quad \text{i=1, 2, 3… n} \tag{12}$$

$$\frac{\partial Z}{\partial \alpha} = -2\sum \left(Bp_i - \alpha A_i - \beta T_i - \gamma W_i - \lambda P_i - \delta\right)A_i = 0 \tag{13}$$

$$\frac{\partial Z}{\partial \beta} = -2\sum \left(Bp_i - \alpha A_i - \beta T_i - \gamma W_i - \lambda P_i - \delta\right)T_i = 0 \tag{14}$$

$$\frac{\partial Z}{\partial \gamma} = -2\sum \left(Bp_i - \alpha A_i - \beta T_i - \gamma W_i - \lambda P_i - \delta\right)W_i = 0 \tag{15}$$

$$\frac{\partial Z}{\partial \lambda} = -2\sum \left(Bp_i - \alpha A_i - \beta T_i - \gamma W_i - \lambda P_i - \delta\right)P_i = 0 \tag{16}$$

$$\frac{\partial Z}{\partial \delta} = -2\sum \left(Bp_i - \alpha A_i - \beta T_i - \gamma W_i - \lambda P_i - \delta\right)_i = 0 \tag{17}$$

Hence from equation (13),

$$-2\sum \left(Bp_i - \alpha A_i - \beta T_i - \gamma W_i - \lambda P_i - \delta\right)A_i = 0$$

$$\therefore \alpha \sum A_i^2 + \beta \sum T_i A_i + \gamma \sum W_i A_i + \lambda \sum P_i A_i + \delta \sum A_i = \sum Bp_i A_i \tag{18}$$

Also from (14),

$$-2\sum \left(Bp_i - \alpha A_i - \beta T_i - \gamma W_i - \lambda P_i - \delta\right)T_i = 0$$

$$\therefore \alpha \sum A_i T_i + \beta \sum T_i^2 + \gamma \sum W_i T_i + \lambda \sum P_i T_i + \delta \sum T_i = \sum Bp_i T_i \tag{19}$$

Also from (15),

$$-2\sum \left(Bp_i - \alpha A_i - \beta T_i - \gamma W_i - \lambda P_i - \delta\right)W_i = 0$$

$$\therefore \alpha \sum A_i W_i + \beta \sum T_i W_i + \gamma \sum W_i^2 + \lambda \sum P_i W_i + \delta \sum W_i = \sum Bp_i W_i \tag{20}$$

Also from (16),

$$-2\sum \left(Bp_i - \alpha A_i - \beta T_i - \gamma W_i - \lambda P_i - \delta\right)P_i = 0$$

$$\therefore \alpha\sum A_iP_i + \beta\sum T_iP_i + \gamma\sum W_iP_i + \lambda\sum P_i^2 + \delta\sum P_i = \sum Bp_iP_i \tag{21}$$

Also from (17),

$$-2\sum\left(Bp_i - \alpha A_i - \beta T_i - \gamma W_i - \lambda P_i - \delta\right) = 0$$

$$\therefore \alpha\sum A_i + \beta\sum T_i + \gamma\sum W_i + \lambda\sum P_i + 10\delta = \sum Bp_i \tag{22}$$

i=1, 2…, n. But for this research, n = 10.

Meanwhile equations (18), (19), (20), (21) and (22) are to be solved simultaneously for values of: $\alpha, \beta, \gamma, \lambda$ *and* δ.

2.3. Research Instrument Used

The research instrument used is known as the random sampling technique. This is a situation where a certain sample of the Taraba State's community members was randomly made to represent the entire population of the university in the research. However, in the questionnaire there are questions designed to checkmate fake responses. Wherever any element of fake response is discovered, the questionnaire is ignored accordingly. 100 copies of questionnaire were distributed. But only 10 copies which satisfied our acceptability test were considered. We attached a fake response test (F.R) or acceptability test to each questionnaire such which any one that becomes successful was considered for the research.

Table 1. *Questionnaire and Measured data Gathered from Federal University Wukari Community of Taraba State of Nigeria.*

HBp (mm Hg)	Age (yrs)	Temperature (°C)	Weight (Kg)	Pulse rate (b/min)
111	23	36.6	66.1	62
114	22	36.1	48.5	83
117	25	36.1	59.5	61
122	23	36.9	58.2	86
129	23	36.2	56.7	72
130	23	37	75.1	91
132	26	36.8	66.1	80
139	26	36.9	75.8	91
156	25	36.5	70.1	59
160	28	36.4	75.1	58

2.4. Evaluation of the Equation Constants Using the Questionnaire Data in Table 1

Solving equation (18), (19), (20), (21) and (22) in this section above simultaneously, where from the Table 1 above.

Table 2. *Multiplication and Summation of the Questionnaire and Measured data in Table 1.*

HBp (mmHg)	Age (Yrs)	T (°C)	W (Kg)	Pulse (b/min)	A^2	T^2	W^2	P^2	AT
111	23	36.6	66.1	62	529	1339.56	4369.21	3844	841.8
114	22	36.1	48.5	83	484	1303.21	2352.25	6889	794.2
117	25	36.1	59.5	61	625	1303.21	3540.25	3721	902.5
122	23	36.9	58.2	86	529	1361.61	3387.24	7396	848.7
129	23	36.2	56.7	72	529	1310.44	3214.89	5184	832.6
130	23	37	75.1	91	529	1369	5640.01	8281	851
132	26	36.8	66.1	80	676	1354.24	4369.21	6400	956.8
139	26	36.9	75.8	91	676	1361.61	5745.64	8281	959.4
156	25	36.5	70.1	59	625	1332.25	4914.01	3481	912.5
160	28	36.4	75.1	58	784	1324.96	5640.01	3364	1019.2
$\sum HBp =$ 1310	$\sum A = 244$	$\sum T =$ 365.5	$\sum W =$ 651.2	$\sum P = 743$	$\sum A^2 =$ 5986	$\sum T^2 =$ 13360.1	$\sum W^2 =$ 43172.72	$\sum P^2 =$ 56841	$\sum AT =$ 8918.7

Table 3. *The Next Multiplication and Summation of data in table 1 above.*

AW	AP	TW	TP	WP	BpA	BpT	BpW	BpP
1520.3	1426	2419.26	2269.2	4098.2	2553	4062.6	7337.1	6882
1067	1826	1750.85	2996.3	4025.5	2508	4115.4	5529	9462
1487.5	1525	2147.95	2202.1	3629.5	2925	4223.7	6961.5	7137
1338.6	1978	2147.58	3173.4	5005.2	2806	4501.8	7100.4	10492
1304.1	1656	2052.54	2606.4	4082.4	2967	4669.8	7314.3	9288
1727.3	2093	2778.7	3367	6834.1	2990	4810	9763	11830
1718.6	2080	2432.48	2944	5288	3432	4857.6	8725.2	10560
1970.8	2366	2797.02	3357.9	6897.8	3614	5129.1	10536.2	12649
1752.5	1475	2558.65	2153.5	4135.9	3900	5694	10935.6	9204
2102.8	1624	2733.64	2111.2	4355.8	4480	5824	12016	9280
$\sum AW =$ 15989.5	$\sum AP =$ 18049	$\sum TW =$ 23818.67	$\sum TP =$ 27181	$\sum WP =$ 48352.4	$\sum BpA =$ 32175	$\sum BpT =$ 47888	$\sum BpW =$ 86218.3	$\sum BpP =$ 96784

Using the data collected for equations (19), (19), (20), (21) and (22) as evaluated in Table 2 and 3, we have that:

$$\sum H_i Bp_i = 1310,\ \sum A_i = 244,\ \sum T_i = 365.5,\ \sum W_i = 651.2,\ \sum P_i = 743,\ \sum A_i^2 = 5986\ \sum T_i^2 = 13360.09,$$
$$\sum W_i^2 = 43172.72,\ \sum P_i^2 = 56841,\ \sum A_i T_i = 8918.7\ \sum A_i W_i = 15989.5,\ \sum A_i P_i = 18049,\ \sum T_i W_i = 23818.67,$$
$$\sum T_i P_i = 27181,\ \sum W_i P_i = 48352.4,\ \sum Bp_i A_i = 32175,\ \sum Bp_i T_i = 47888,\ \sum Bp_i W_i = 86218.3,\ \sum Bp_i P_i = 96784$$

$$\alpha 5986 + \beta 8918.7 + \gamma 15989.5 + \lambda 18049 + \delta 244 = 32175 \tag{23}$$

$$\alpha 8918.7 + \beta 13360.09 + \gamma 23818.67 + \lambda 27181 + \delta 365.5 = 47888 \tag{24}$$

$$\alpha 15989.5 + \beta 23818.67 + \gamma 43172.72 + \lambda 48352.4 + \delta 651.2 = 86218.3 \tag{25}$$

$$\alpha 18049 + \beta 27181 + \gamma 48352.4 + \lambda 56841 + \delta 743 = 96784 \tag{26}$$

$$\alpha 244 + \beta 365.5 + \gamma 651.2 + \lambda 743 + \delta 10 = 1310 \tag{27}$$

Hence, solving equation (23), (24), (25), (26) and (27) above simultaneously gives

$$\alpha = 3.94487$$
$$\beta = -9.93656$$
$$\gamma = 0.89813$$
$$\lambda = 0.02314$$
$$\delta = 337.72129$$

Also, putting the values in equation (11) yields,

$$Bp = 3.94487A - 9.93656T + 0.89813W + 0.02314P + 337.72129,\ Bp \geq 0 \tag{28}$$

Thus, equation (28) is the developed model for estimating the blood pressure (i.e. High Bp only) of human beings (Nigerians to be specific).

3. Results and Discussion

In the concluding part of the previous chapter, data were collected in order to be able to evaluate our emerging model equation constants. Thus, our new model equation now as in equation (28) is;

$$Bp = 3.94487A - 9.93656T + 0.89813W + 0.02314P + 337.72129,\ BP \geq 0$$

3.1. Optimization of the Model

This approach is a technique for programming/optimizing an objective function or a model in order to know whether a model conforms to reality or not. Thus, the first part of our optimizing process is the determination of the model's critical values as below:

From (9) and (23),

$$\begin{aligned} Bp &= \alpha A + \beta T + \gamma W + \lambda P + \delta \\ Bp &= 3.94487A - 9.93656T + 0.89813W + 0.02314P + 337.72129 \end{aligned} \tag{29}$$

For ease of analysis, we recall from the collected data in Table 1 and recommendations from literatures that the Body Temperature of humans assumes maximum (of approximately 36°C) at turning point and it is 100% for all. But $100\% = \frac{100}{100} = 1$, hence for our model let T=1 and P=1 (for same reason) then our reduced Bp model gives;

$$Bp = \alpha A + \gamma W + \delta + 0 + 0 \tag{30}$$

Meanwhile, to optimise and deduce the nature of the extreme value of our model, we recall generally that, given a function f(x, y) that obeys the continuity of the partial derivatives and we

Let: $A = \frac{\partial^2 f}{\partial x^2}$; $B = \frac{\partial^2 f}{\partial x \partial y}$; and $C = \frac{\partial^2 f}{\partial y^2}$; then,

If $B^2 - AC < 0$, then f(x, y) has extreme value at (x_o, y_o) and minimum if $A > 0$ and it is maximum if $A < 0$

If $B^2 - AC > 0$, or $AC < B^2$ then f(x, y) has no extreme value. That is, it has a saddle point at (x_o, y_o).

If $B^2 - AC = 0$, then no information is derivable about its extreme values. And it means no maximum or minimum value for the extreme vale.

Similarly, importing the same idea in our reduced model equation variables,

$$\frac{\partial \mathrm{B_p}}{\partial \mathrm{A}} = \alpha, \frac{\partial B_p}{\partial W} = \gamma$$

But from the above also,

$$\left.\begin{aligned} &\frac{\partial^2 \mathrm{B_p}}{\partial \mathrm{A}^2} = 0 \\ &\frac{\partial^2 B_p}{\partial W^2} = 0 \\ &And \ \frac{\partial^2 B_p}{\partial A \partial W} = \frac{\partial}{\partial A}\left(\frac{\partial B_p}{\partial W}\right) \\ &\therefore \frac{\partial^2 B_p}{\partial A \partial W} = 0 \end{aligned}\right\} \quad (31)$$

Since from our general argument above, we have that,

$$B^2 - AC = 0 \quad (32)$$

(Then this means that a human Bp has no information of maximum or minimum derivable about its extreme values or it thus has no local *extremum* or has no specific optimal value)

This result in equation (32) showing no maximum/minimum value for human's Blood pressure is what accounts for why human Bp (if not properly managed) under the supervision of medical professionals could rise uncontrollably to any alarming height or drop drastically to a dreadful value. It also accounts for why there are no such awards as world highest/lowest Bp holder unlike the case of the tallest man in the world, shortest man in the world, world heaviest man etc.

3.2. Correlation Relationship Between the Model Data and the Actual Questionnaire/Measured Data

After the model became ready, the researchers conducted a pilot test using some people living in Wukari Local Government community (the research area) to see whether or not the model conforms to reality or not. The test confirms that the model is suitable for the people since the correlation relationship between the model data generated and the actual measurement done for the people is a strong relationship (approximately 0.8 or 80% accurate).

Meanwhile, the fact that the correlation result is not 100% confirms the view of [3] that, model parameters relationships are inexact. The reason being that, the solution is dependent on the parameters decided to be considered by the modeller. In the same vein, the model is developed and validated in Taraba State, if considered logical could be used to make a universal generalization about the Bp of every other group of persons in the world.

However, the correlation result is given below.

Let X= actual questionnaire and Y= model data

$$\left.\begin{aligned} \overline{X} &= \frac{\sum X}{n} = \frac{1310}{10} = 131 \\ \overline{Y} &= \frac{\sum Y}{n} = \frac{1310.003774}{10} = 131.003774 \end{aligned}\right\} \quad (33)$$

Table 4. *Correlation Coefficient Computation tabular Values.*

X	Y	$X-\overline{X}$	$Y-\overline{Y}$	$(X-\overline{X})^2$	$(Y-\overline{Y})^2$	$(X-\overline{X})(Y-\overline{Y})$
111	125.576277	-20	-5.4241004	400	29.42086515	108.482008
114	111.278539	-17	-19.7218384	289	388.9509099	335.2712528
117	132.483499	-14	1.4831216	196	2.19964968	-20.7637024
122	116.05544	-9	-14.9449374	81	223.3511539	134.5044366
129	121.339879	-2	-9.6604984	4	93.32522934	19.3209968
130	130.355883	-1	-0.6444944	1	0.415373032	0.6444944
132	135.840095	1	4.8397176	1	23.42286645	4.8397176
139	143.81284	8	12.8124626	64	164.1591979	102.4997008
156	137.982773	25	6.9823956	625	48.75384831	174.55989
160	155.278549	29	24.2781716	841	589.4296162	704.0669764
				$\sum$= 2502	$\sum$=1563.42871	$\sum$=1563.425771

Correlation formula is,

$$\left.\begin{aligned} r_{x,y} &= \frac{\sum_{i=1}^{10}\left(X_i - \overline{X}\right)\left(Y_i - \overline{Y}\right)}{\sqrt{\sum_{i=1}^{10}\left(X_i - \overline{X}\right)^2 \sum_{i=1}^{10}\left(Y_i - \overline{Y}\right)^2}} = \frac{1563.425771}{\sqrt{2502 \times 1542871}} = \frac{1563.425771}{\sqrt{3911698.632}} = \frac{1563.425771}{1977.801464} \\ r_{x,y} &= 0.790486709 \end{aligned}\right\} \quad (34)$$

3.3. Discussion of Results

From our optimization result in equation (31) above, it was constant noticed at various levels of our model analysis that there is no particular Bp of human beings that can be called maximum or minimum Bp. This is consequent upon obtaining either minimum or maximum values as the models extreme/optimal value as in equation (32) above. This tends to substantiate the reason why cardiovascular heart attack reading varies i.e. heart attack patient's records show that their Bp varies at the time of the attack. There is no particular maximum measurement at the time of any cardiovascular attack/disease. It means that a person's Bp cannot be constant as he does not have maximum or minimum value. Equally, the developed model equation is relevant as compared to other existing models because, the model gives rise to simplicity of measures and can be utilized in remote areas in the absence of physically produced sphygmomanometers. It is also relevant in checkmating cases of false report of data from the available Bp machines.

4. Conclusion

From the optimisation results in equation (32) above, it could be remarked that no human being can have any blood pressure value that can be called a maximum or minimum unlike the case of the tallest man in the world, shortest man in the world, world heaviest man etc. This means that human beings could have a 'very high' or 'very low' Bp and will still be alive but the implication of such, as harnessed by this study is that people with these extreme Bp results will definitely generate some medical concerns. Based on this consequences and medical reasons people are not encouraged to have certain Bp value because of other extreme health related illness and issues associated to it.

Finally, the correlation result in section 3.3 recommends the model to be useful to the people. And hence, in view of these medical concerns associated with extreme Bp, every household is encouraged to get their Bp checked regularly using these developed model especially where the Bp gadget will not be within reach. And when using the model as a replacement, the users are referred to the equation (28) where they can use a mini calculator to substitute and compute their Bp data.

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