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Research Article

Role of Blood Pressure on Heart Patients

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Abstract

Elevated blood pressure is a fundamental cardiovascular risk factor. Systolic and diastolic blood pressure are mainly considered in hypertension management. The current report considers the role of BP for some heart patients. It is found that mean BP is higher at older ages ($P < 0.0001$). It is higher for diabetes heart patients ($P = 0.0836$), and it increases as the maximum heart rate ($P = 0.0092$) rises, or ST depression induced by exercise relative to rest ($P = 0.01366$) increases. It is higher for the patients having resting electrocardiographic result at normal ($P=0.0388$), or thalasemia at normal level ($P = 0.1189$) than others. Variance of BP is higher at older ages ($P=0.0091$), or patients without chest pain ($P = 0.1113$).

Keywords: *Role of Blood; Heart Patients*

Introduction

Diastolic blood pressure (DBP) and Systolic blood pressure (SBP) are defined by current guidelines [1-3]. Generally, DBP has been considered as the precedence in hypertension management. However, there are several principal evidences that SBP is higher to DBP as a cardiovascular events predictor [4,5]. In practice, elevated blood pressure is directly correlated with ischaemic heart disease for 47%, and 54% of stroke. It highly affects nearly 30% of the adult population [1,3,5]. Practically, cardiac factors such as DBP, SBP, heart rate, cardiac index, ejection fraction are closely associated with each other [5-8]. High BP is managed by pharmacotherapy. Generally, many risk factors such as lifestyle, family history, sleep apnoea and many biochemical factors are associated with elevated BP [9, 10].

The present report examines the determinants of BP for some heart patients based on probabilistic modeling. To the best of our knowledge, it has not been studied by any suitable statistical modeling. The report has derived many interesting determinants of BP based on joint modeling of both mean and variance of BP, which have not been reported in any previous article. Two distributions namely Log-normal and Gamma are assumed for the considered response BP.

Materials and Methods

Materials

Determinants of BP for some heart patients is identified in the report considering a real data set of 303 heart patients with 14 study characters, which is reported in UCI machine learning repository. The data set was donated by David W. Aha [(aha **'@'** ics.uci.edu) (714) 856 - 8779]. Interested readers can locate the data set in UCI machine learning repository. Data collection method and its patients population are well described by Detrano., *et al* [11]. These are not redisplayed herein. The 14 study characters are as follows: Age (in years), Sex (1 = male; 0 = female), Serum cholestoral (Chol) (in mg/dl), Chest pain (CP) (1 = typical angina; 2 = atypical angina, 3 = non-anginal pain or asymptomatic), Resting blood pressure (Trestbps) (in mm Hg on admission to the hospital), Maximum heart rate achieved (Thalach), Fasting blood sugar (Fbs) ((Fbs > 120 mg/dl) (1 = true; 0 = false)), Exercise induced angina (Exang) (1 = yes; 0 = no), ST depression induced by exercise relative to rest (Oldpeak), Resting electrocardiographic (Restecg) (resting electrocardiographic results -- value 0 = normal; 1 = having ST-T wave abnormality (T wave inversions and/or ST elevation or depression of > 0.05 mV)), Ca (number of major vessels (0 - 3) colored by fluoroscopy), Slope (the slope of the peak exercise ST segment -- value 1 = upsloping, 2 = flat, 3 = downsloping), Thalassemia (Thal) (3 = normal; 6 = fixed defect; 7= reversable defect), Target (num: diagnosis of heart disease (angiographic disease status) value 0:< 50% diameter narrowing; 1: > 50% diameter narrowing (in any major vessel: attributes 59 through 68 are vessels)).

Statistical methods

The data set is a multivariate form, and the response resting blood pressure is heterogeneous, positive and continuous, which can be modeled by using appropriate transformation if the variance is stabilized under that transformation. But resting BP is not stabilized. Therefore, it should be modeled by joint generalized linear models (JGLMs). Thus, we have examined resting BP using JGLMs under both the Log-normal and Gamma distributions, which are clearly given in the book by Lee., *et al* [12]. It is also well discussed in many research papers by Lesperance and Park [13], Das and Lee [14], Qu., *et al.* [15], which are not reported herein. For details on JGLMs discussions, readers can see the book by Lee., *et al* [12].

Statistical and graphical analysis

The response resting BP is treated as the dependent variable and the remaining other factors and variables are treated as the independent variables. Herein resting BP has been modeled by JGLMs under both the Gamma and Log-normal distributions. The final model has been accepted considering the lowest Akaike information criterion (AIC) value (within each class), which minimizes both the squared error loss and predicted additive errors. AIC rule is clearly described in the book by Hastie., *et al* [16]. All the included effects in both the models are not significant. The resting BP analysis results are displayed in Table 1. According to AIC rule (Table 1), Log-normal fit (AIC = 2518) gives better than the Gamma fit (AIC = 2520.157).

Model	Factors	Log-normal model fit				Gamma model fit			
		estimate	s.e.	t-value	P- value	Estimate	s.e.	t-value	P- value
Mean	Constant	4.5199	0.08574	52.717	<0.0001	4.5123	0.08600	52.471	<0.0001
	Age	0.0037	0.00085	4.362	<0.0001	0.0039	0.00085	4.557	<0.0001
	Cholestoral	0.0002	0.00014	1.141	0.2547	0.0002	0.00014	1.211	0.2269
	Thalach	0.0009	0.00036	2.622	0.0092	0.0010	0.00036	2.677	0.0078
	Oldpeak	0.0166	0.00670	2.481	0.0137	0.0164	0.00672	2.437	0.0154
	Fbs	0.0352	0.02029	1.736	0.0836	0.0356	0.02032	1.751	0.0809
	Restecg	-0.0289	0.01392	-2.075	0.0389	-0.0285	0.01396	-2.044	0.0418
	Thal 2	-0.0474	0.03030	-1.564	0.1189	-0.0492	0.03039	-1.618	0.1067
	Thal 3	-0.0321	0.03011	-1.068	0.2864	-0.0316	0.03020	-1.047	0.2959
Dispersion	Constant	-5.521	0.5348	-10.323	<0.0001	-5.509	0.5365	-10.269	<0.0001
	Age	0.025	0.0094	2.625	0.0091	0.025	0.0094	2.606	0.0096
	Chest pain 2	-0.398	0.2491	-1.597	0.1113	-0.387	0.2489	-1.555	0.1.210
	Chest pain 3	0.014	0.1836	0.079	0.9371	-0.001	0.1835	-0.008	0.9936
AIC		2518				2520.157			

Table 1: *Results for mean and dispersion models for resting BP from Gamma and Log-Normal fit.*

Data produced resting BP probabilistic model should be examined by model diagnostic tools before accepting it as the valid correct model, which presents all valid decisions. The developed Log-normal fitted resting BP model (Table 1) has been diagnosed by model checking plots in Figure 1. Figure 1(a) presents the resting BP Log-normal fitted (Table 1) absolute residuals plot against the fitted values, which is exactly a flat straight line, indicating that variance is constant with the running means. Figure 1(b) reveals the mean resting BP Log-normal fitted normal probability plot (Table 1), which does not indicate any lack of fit. Thus, both the Figures 1(a) and 1(b) support that that the Log-normal model fits the data well (Table 1).

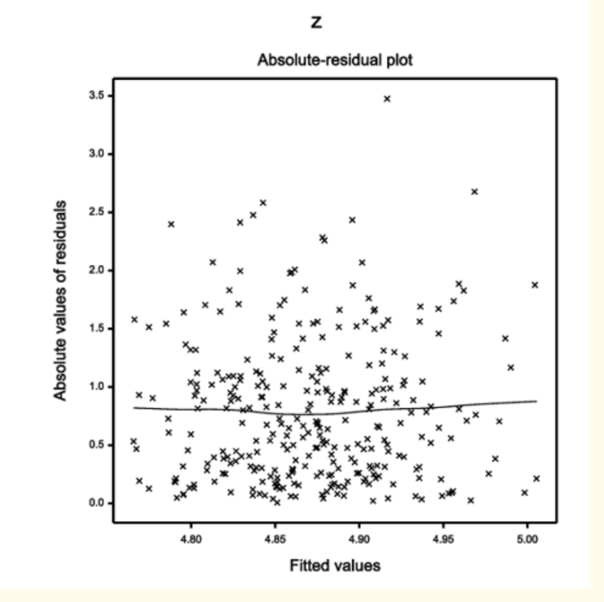

Figure 1A

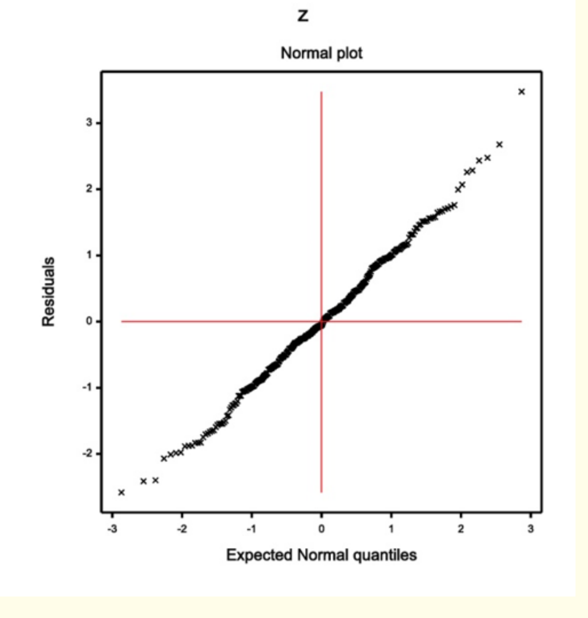

Figure 1B

Figure 1: *For the joint Log-normal fitted resting BP model (Table 1), the (a) absolute residuals plot with respect to the fitted values, and (b) the normal probability plot for the mean model.*

Results

Summarized JGLMs results for resting BP analysis are displayed in Table 1. Log-normal fitted resting BP model (Table 1) indicates that mean BP is higher at older ages (P < 0.0001). It is higher for diabetes heart patients (P = 0.0836), and it increases as the maximum heart rate (P = 0.0092) rises, or ST depression induced by exercise relative to rest (P = 0.01366) increases. It is higher for the patients having resting electrocardiographic result at normal (P = 0.0388), or thalasemia at normal level (P = 0.1189) than others. Variance of BP is higher at older ages (P = 0.0091), or patients without chest pain (P = 0.1113).

Log-normal fitted resting BP mean (μ) model (from Table 1) is

$\hat{Z}$ = Log (Resting BP) = 4.5199 + 0.0037 Age + 0.0002 Chol + 0.0009 Thalach + 0.0166 Oldpeak + 0.0352 Fbs – 0.0289 Restecg - 0.0474 (Thal 2) - 0.0321 (Thal 3),

and the Log-normal fitted resting BP variance (σ^2) model is

$\widehat{\sigma^2}$ =exp. (-5.521 + 0.025 Age – 0.398 CP(level 2) - 0.014 CP(level 3)).

The mean and variance of resting BP models are given above by two equations. It is noted that mean resting BP is expressed by Age, Cholestoral, Thalach, Oldpeak, Fbs, Restingecg, Thal while its variance is presented by Age and Chest pain only.

Discussion

Final Log-normal fitted mean resting BP model (Table 1) shows that it is positively associated with age (P < 0.0001), concluding that BP is higher for older heart patients than younger. It is positively associated with maximum heart rate (Thalach) (P = 0.0092), interpreting that BP increases as Thalach increases. In addition, resting PB is positively associated with ST depression induced by exercise relative to rest (Oldpeak) (P = 0.01366), indicating that BP rises as Oldpeak increases. Also it is positively associated with Fasting blood sugar (Fbs) ((Fbs > 120 mg/dl) (1 = true; 0 = false)) (P = 0.0836), implying that BP is higher for diabetes heart patients than others. Mean resting BP is negatively associated with resting electrocardiographic (Restecg) (resting electrocardiographic results -- value 0 = normal; 1 = having ST-T wave abnormality (T wave inversions and/or ST elevation or depression of > 0.05 mV)) (P = 0.0389), concluding that BP is higher for heart patients with Restecg at normal level than others. Also, resting BP is negatively partially associated with Thalassemia (Thal) (3 = normal; 6 = fixed defect; 7= reversable defect) (P = 0.1189), concluding that BP is higher for heart patients with Thal at normal level than others. It is partially positively associated with cholesterol level (P = 0.2547), indicating that BP increases as cholestoral level rises. Note that in epidemiology, partially significant factors are considered as confounders in the model. Variance of resting BP is positively associated with age (P = 0.0091), concluding that it is higher at older patients. Also, it is negatively partially associated with Chest pain (CP) (1 = typical angina; 2 = atypical angina, 3= non-anginal pain or asymptomatic) (P = 0.1113), interpreting that it is higher for heart patients with CP at typical angina level.

For the same data set, role of cholestoral and Thalach on resting BP have been studied by Kim., *et al.* [17] and Das., *et al* [18]. This is not reproduced herein. Interested readers go through these articles. Few articles have studied role of resting BP for heart patients based on appropriate modeling, therefore the present results cannot be compared with the earlier results.

Conclusions

Both the Log-normal and Gamma JGLM fits for resting BP have very similar interpretations (Table 1). The standard errors of the estimators in both the models are very small, concluding that estimates are stable. Graphical diagnostic tools and AIC value are used to accept the appropriate model. The current research should have higher faith in these results than those emanating from Log-Gaussian (with constant variance), Logistic regression, multiple linear regression, as the current obtained models have been verified by AIC values, graphical diagnostic tools and comparison between two distributions such as Log-normal and Gamma.

The current report presents many new interesting results to the cardiology literature. Medical experts and heart patients will be benefitted from the present outputs. Resting BP for heart patients should be examined regularly at older ages, and diabetic and thalassemic heart patients.

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Conflict of Interest

The authors confirm that this article content has no conflict of interest.

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