Systolic Blood Pressure: A Research Paper About the Effects of Minerals and the Relationship Between Gender

Aybüke Altuntaş, Gözde Akkaya, Gülin Oğuz

Middle East Technical University

{aybuke.altuntas, gozde.akkaya, gulin.oguz}@metu.edu.tr

1. Abstract

Global changes not only affect the nature, they also affect the human behavior and habits, ranging from eating to substance abuse. Inevitably, there have been changes in the human body as a result of this dynamism. In the first dataset, the impact of minerals on the systolic blood pressure and the factors from the dataset that have the highest explanation rate have been investigated by making use of generalized linear models. After the comparison of these models according to certain criteria, the best model was chosen and the investigation of the relationship between minerals and systolic blood pressure was decided in parallel to this best model.

2. Introduction

The topic of this paper is the behavior of systolic blood pressure controlled under certain factors such as levels of different minerals that are present in the blood, body mass index, gender, alcohol consumption, pulse rate. Even though there is an agreement among majority when it comes to negative effects of substance abuse like alcohol and tobacco, an agreement or general statement about mineral levels, or the number of people that live in a house does not exist. Thus, models that consisted of these factors were constructed and examined in order to come up with helpful answers. In the model building phase, assumptions were not satisfied, a problem that yielded a treatment phase for the model. Transformations on data were applied but still there were no proper conditions to make correct inferences. Although the transformed data did not satisfy the assumptions, examination was proceeded with methods for model adequacy checking.

3. Literature Review

During the research question generating process, an article about the relationship between minerals and blood pressure (Karppanen, 1991) was encountered. In the article it is stated that minerals such as magnesium, potassium, calcium and sodium are crucial in terms of coordinating the blood pressure, to be more specific, adjusting the arterial resistance. According to another study that was published in American Heart Association Journal expresses that men have a higher risk of suffering from cardiovascular diseases when compared to women of the same age who are also pre-menopausal. Moreover, according to observations of the same study, men had approximately 6-10 mmHg higher levels of mean blood pressure on a 24-hour scale. (Reckelhoff, 2001). In the guiding light of the information and findings stated above, research questions are aimed to be answered properly and sufficiently.

4. Data

The dataset has 4884 rows and 15 columns, and it was retrieved from Kaggle, under the

name of National Health and Nutrition Examination Survey. NHANES interviews contain questions that are aimed at dietary, health, socioeconomic and demographic statuses of people. Physiological, medical, dental measurements and laboratory tests which are conducted under the supervision of trained medical personnel are also components of the examination. The dataset that was used in this project is not the full version, it is a reduced version that contains less variables, which are the following: Number of people in the house, estimated household income, gender, age, systolic blood pressure, BMI (body mass index), pulse behavior (regular or irregular), maximum inflation level (level that is obtained by inflating the cuff 30 mmHg more after measuring the pulse), alcohol consumption, sodium, dietary potassium, dietary calcium, magnesium, protein intake, calorie intake, smoking habit.

Research Question 1

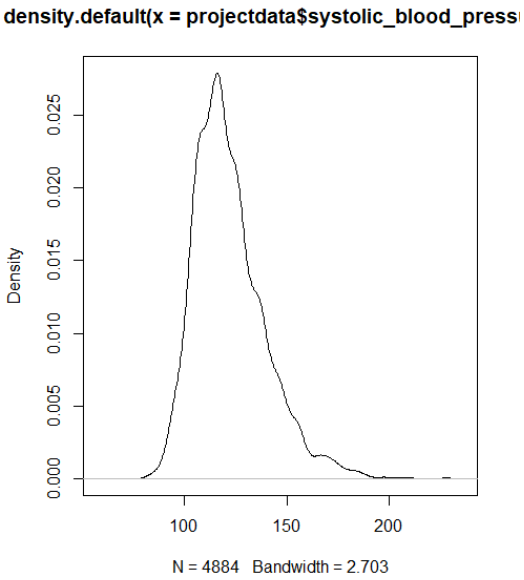
According to H.Karppanen (1991), the mineral elements sodium, potassium, calcium and magnesium play a central role in the normal regulation of blood pressure. In particular, these mineral elements have important interrelationships in the control of arterial resistance. These elements, especially sodium and potassium, also regulate the fluid balance of the body and, hence, influence blood pressure. Evidence shows that the present levels of intake of mineral elements are not optimum for maintaining normal blood pressure and might cause development of arterial hypertension. So we wanted to investigate the relationship of these minerals with blood pressure in our data.

5. Methods

In order to investigate the relationship between the mineral elements(sodium, potassium, calcium and magnesium) and systolic blood pressure, considering the systolic blood pressure is a positive, right-skewed variable, an identity-link and log-link gamma family model, log-link gaussian family model and identity-link inverse gaussian family model are fitted and some analysis are done to compare these models for the purpose of choosing the most proper model for the data.

6. Statistical Results

The outcome variable (systolic blood pressure) is positively skewed since the skewness of the outcome variable which is systolic blood pressure is 1.054181 and also it can be shown from the density plot of systolic blood pressure is right-skewed.



Since the data is not normally distributed (Shapiro-Wilk Normality Test is also considered on the response variable). Shapiro-Wilk Normality Test:

W = 0.94489	p-value < 0.05

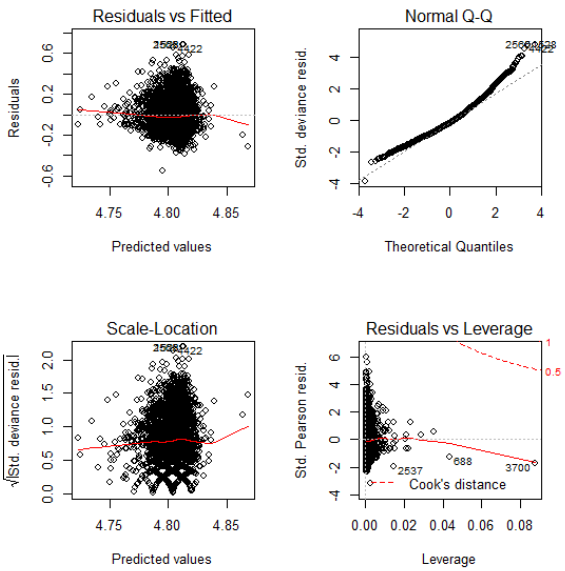
An identity-link and log-link gamma family model, log-link gaussian family model and identity-link inverse gaussian family model are constructed since the outcome variable is right-skewed. To compare these different models, statistical plots, RMSE statistics, goodness of fit test are investigated and compared with each other.

The results of RMSE values of the models:

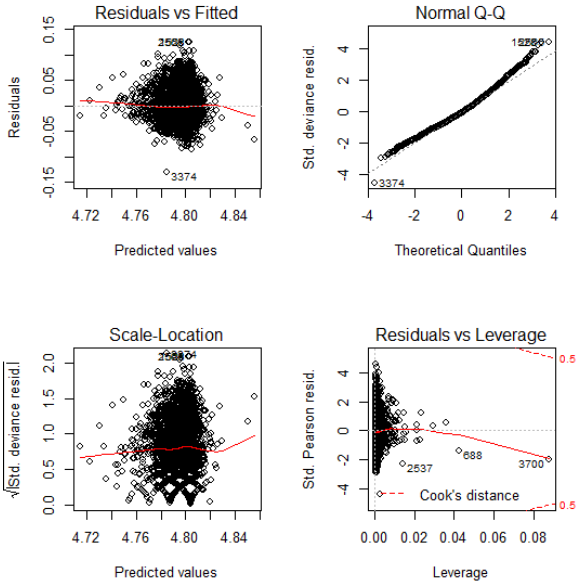
RMSE-log-link gamma	118.6668
RMSE-identity-link gamma	118.6763
RMSE-log-link gaussian	118.6668
RMSE-identity-link-inverse gaussian	17.48444

Statistical Plots of the models:

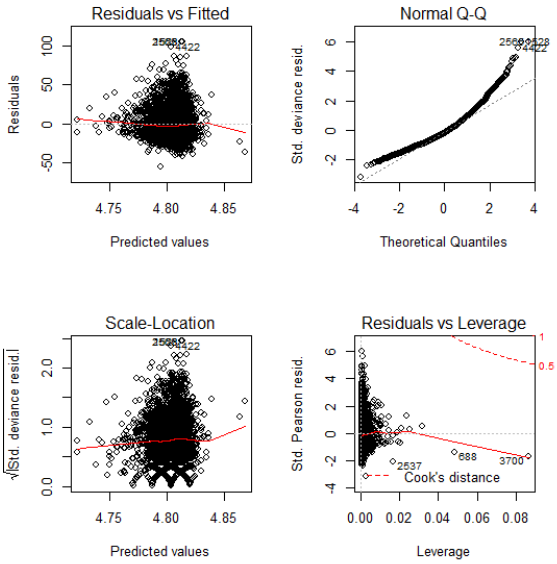
The plot of log-link gamma family model:



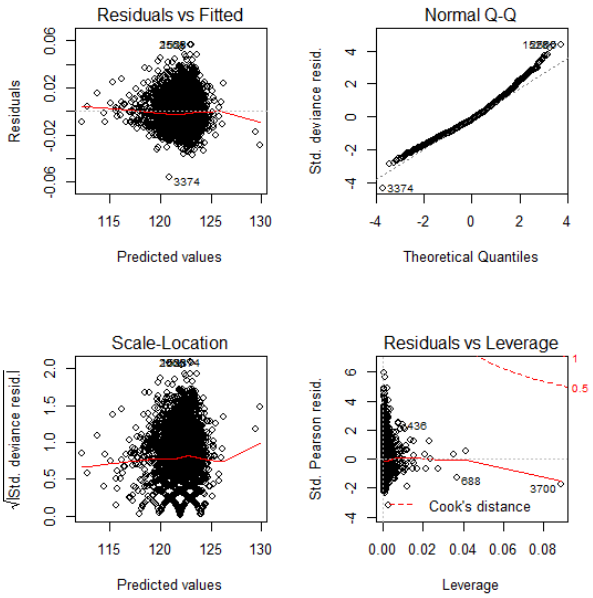
The plot of identity-link gamma family model:



The plot of log-link gaussian family model:



The plot of identity-link inverse gaussian family model:



The results of VIF values of the models:

Log-link gamma family model

sodium	Dietary potassium	Dietary calcium	magnesium
1.862	4.102	1.719	3.498

Identity-link gamma family model

sodium	Dietary potassium	Dietary calcium	magnesium
1.864	4.104	1.721	3.497

Log-link gaussian family model

sodium	Dietary potassium	Dietary calcium	magnesium
1.848	4.089	1.707	3.502

Identity-link inverse gaussian family model

sodium	Dietary potassium	Dietary calcium	magnesium
1.882	4.121	1.738	3.493

The VIF values indicates that there are no serious multicollinearity problem in the models.

The results of goodness of fit:

Log-link gamma family model

Null deviance	94.410 on 4883 df
Residual deviance	93.886 on 4879 df

Identity-link gamma family model

Null deviance	3.9645 on 4883 df
Residual deviance	3.9441 on 4879 df

Log-link gaussian family model

Null deviance	1500858 on 4883 df
Residual deviance	1493001 on 4879 df

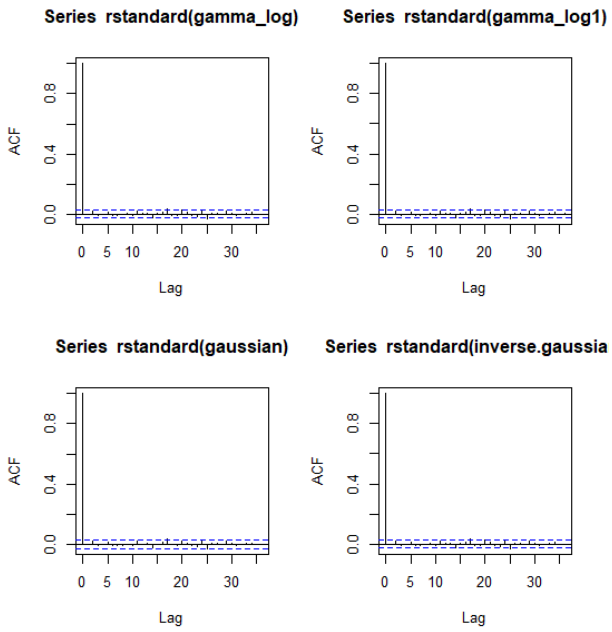
Identity-link inverse gaussian family model

Null deviance	0.76100 on 4883 df
Residual deviance	0.75675 on 4879 df

The results of goodness-of-fit test for each model implies:

Log-link gamma family model is a good fit since the deviance goodness of fit statistic is 93.886 with 4879 degrees of freedom. Identity-link gamma family model is good fit since the deviance goodness of fit statistic is 3.9441 with 4879 degrees of freedom. Log-link gaussian family model is not a good fit since the deviance goodness of fit statistic is 1493001 with 4879 degrees of freedom. Identity-link inverse gaussian family model is a good fit since the deviance goodness of fit statistic is 93.886 with 4879 degrees of freedom.

Independence of residuals:



According to the ACF, the residuals are independent for all the models.

7. Conclusion

By considering different criterias for different fitted models, the identity-link inverse gaussian family model is chosen to investigate the relationship of these minerals with blood pressure in our data for the following reasons:

When considering VIF values, all the models have no serious multicollinearity problem and, the residuals are independent for all the models. According to the goodness of fit, except for log-link gaussian family model, the rest of them are good fits. Considering the Q-Q plot and RMSE, identity-link inverse gaussian model behaves well compared to others. Thus, Identity-link inverse gaussian model is chosen to study the relationship of the minerals with blood pressure in our data.

	Estimate	Std error	P value
Intercept	1.233e+02	5.974e-01	<0.05
sodium	-3.474e-04	1.810e-04	0.054973
dietary potassium	1.136e-03	3.947e-04	0.004034
dietary calcium	-1.878e-03	5.352e-04	0.000454
magnesium	-3.662e-03	2.887e-03	0.204726

According to the summary of the chosen model, sodium and magnesium are not statistically significant while dietary potassium and dietary calcium are statistically significant. It can be concluded from the analysis that systolic blood pressure has negative relationship with dietary potassium and dietary calcium.

Research Question 2

Recent studies have demonstrated that men are more vulnerable to cardiovascular diseases when compared to women, when both genders are in the same age and women are pre-menopausal. (Reckelhoff, 2001). Moreover, after measuring the blood pressure levels of both men and women in a 24-hour period, it was observed that men had 6 to 10 mmHg higher levels of mean blood pressure level. According to this information, we decided to investigate

whether or not there actually is a statistical difference between men and women when it comes to mean blood pressure levels.

1. Methods

To investigate whether the mean of systolic blood pressure between genders is statistically different or not, Kruskal-Wallis Test is used since ANOVA assumptions are not met. For checking ANOVA assumptions, Shapiro-Wilk Normality Test and Levene Test are considered.

2. Statistical Results

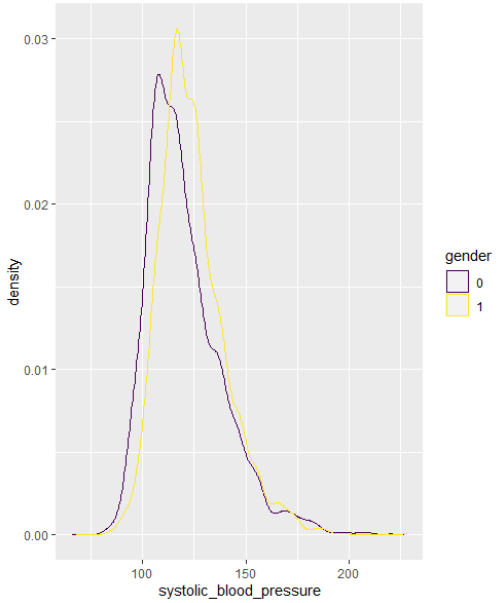
There are two levels for gender variable.

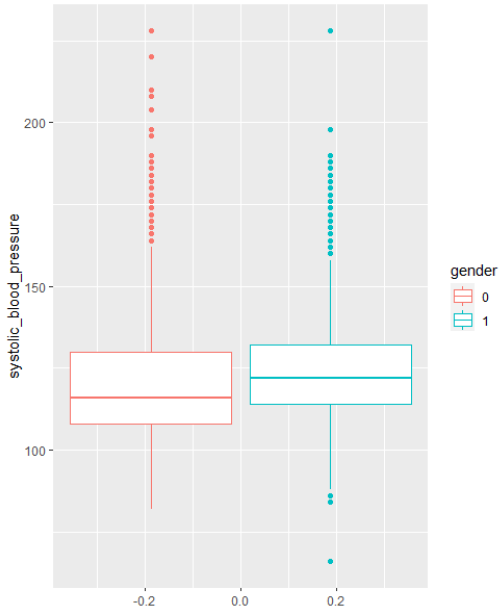
"0" for female	"1" for male

Summary Statistics:

gender	variable	n	mean	sd
0	Systolic blood pressure	2523	120.	18.4
1	Systolic blood pressure	2361	124.	16.3

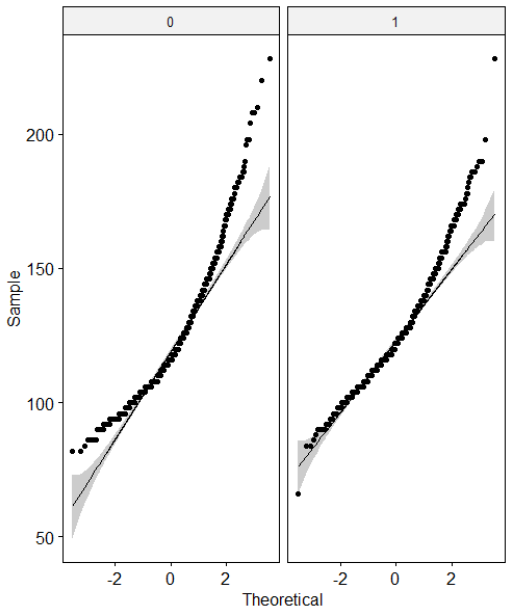
To summarize the summary statistics table, the mean of systolic blood pressure for females is 120 and the mean of systolic blood pressure for males is 124 when other variables are held constant.





As it can be seen from the plots above, the mean of systolic blood pressure for males is higher than females. Besides these visualization analysis, the main concern is that the difference of the mean of systolic blood pressure is statistically significant or not. For this purpose, firstly, the ANOVA assumptions are checked which are normality assumptions among treatment groups (male and female) and equal variances assumption.

Normality Assumption:



The plot shows that the residuals from both male and female are not normally distributed.

Shapiro-Wilk Test:

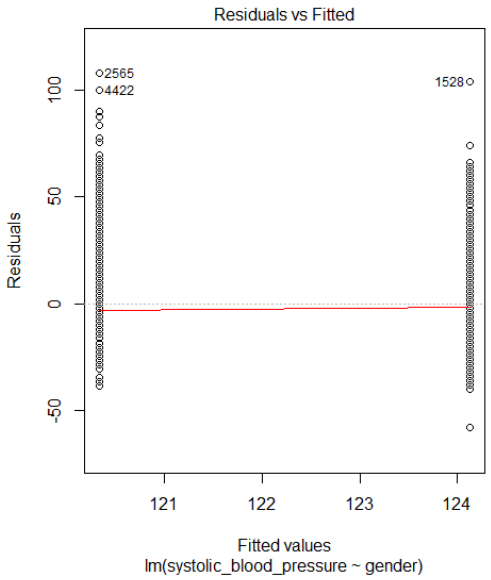
variable	statistic	p.value
residuals	0.939	<0.05

gender	variable	statistic	p.value
0	Systolic blood pressure	0.925	<0.05
1	Systolic blood pressure	0.955	<0.05

Shapiro-Wilk Test shows that the residuals for the model and the residuals from both male and female group are not normally distributed. Thus, the normality assumption of ANOVA is violated.

Equal Variances Assumption:

To check the equality of variances of treatment groups (male and female), Levene's Test is conducted.



Levene's Test

df1	df2	statistic	p-value
1	4882	18.1	0.0000216

Since the p-value is less than the alpha value, there is enough evidence to say that there is a statistically significant difference between variances of groups. Therefore, equal variances assumption is violated.

Since the ANOVA assumptions are not met, Kruskal Wallis Test, which is the non-parametric alternative to ANOVA test, is constructed.

Kruskal Wallis rank sum test:

K-W chi-squared	df	p-value
109.98	1	<0.05

We have enough evidence to say that the mean of the systolic blood pressure between genders are statistically different from each other.

References

Karppanen, H. (1991). Minerals and Blood Pressure. *Annals of Medicine, 23*(3), 299–305. https://doi.org/10.3109/07853899109148064

Reckelhoff, J. F. (2001). Gender differences in the regulation of Blood Pressure. *Hypertension, 37*(5), 1199–1208. https://doi.org/10.1161/01.hyp.37.5.1199